NAVWEPS REPORT 7291

WIND-TUNNEL TESTS OF THE NAVY LOW-DRAG BOMB AT ANGLES OF ATTACK UP TO 70 DEGREES (U)

4 OCTOBER 1960

U. S. NAVAL ORDNANCE LABORATORY
WHITE OAK, MARYLAND

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WIND-TUNNEL TESTS OF THE NAVY LOW-DRAG BOMB AT ANGLES OF ATTACK UP TO 70 DEGREES

Prepared by

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ABSTRACT: This report presents the results of an investigation in the NOL Supersonic Tunnel No. 1 to measure the static stability and drag of the Navy low-drag bomb at angles of attack up to 70 degrees. These data were obtained at Mach numbers of 0.40, 0.60, 0.80, 1.53, 1.76, and 2.03.

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The purpose of this investigation was to obtain stability and drag data at high angles of attack on the Navy low-drag bomb for trajectory calculations. The wind-tunnel test was performed at the request of the Naval Weapons Laboratory (reference (a)), under Task Number 526. Other reports on the low-drag bomb shape are given in references (b) through (m).

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Captain, USN
Commander

R. KENNETH LOBB
By direction

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WIND-TUNNEL TESTS OF THE NAVY LOW-DRAG BOMB AT ANGLES OF ATTACK UP TO 70 DEGREES

INTRODUCTION

1. The low-drag bomb is a standard Navy external store carried by high speed aircraft. The MK 81, 82, 83, and 84 bombs use the low-drag bomb shape as tested in this investigation.

2. This report gives the results of a wind-tunnel investigation to determine the stability and drag coefficients at high angles of attack (up to 70 degrees). The coefficients are necessary for trajectory calculations. The data were obtained at Mach numbers of 0.40, 0.60, 0.80, 1.53, 1.76, and 2.03.

AERODYNAMIC SYMBOLS

A	reference area (based on maximum body diameter)
c.g.	center of gravity, 3.64 calibers forward from the base
C_A	axial force coefficient (F_A/qA)
C_θ	pitching moment coefficient (M_θ/qAd)
C_N	normal force coefficient (F_N/qA)
C_Y	side force coefficient (F_Y/qA)
C_ϕ	rolling moment coefficient (M_ϕ/qAd)
C_ψ	yawing moment coefficient (M_ψ/qAd)
d	reference diameter (maximum body diameter = caliber) (1.5 in)
F_A	axial force (lbs)
F_N	normal force (lbs)
F_Y	side force (lbs)
M_θ	pitching moment (in-lbs)
M_ϕ	rolling moment (in-lbs)
M_ψ	yawing moment (in-lbs)
q	dynamic pressure (psi)

α angle of attack (deg)

ϕ angle of roll (ϕ = 0° with fins in horizontal and vertical planes respectively) (deg)

MODEL, TEST TECHNIQUES, AND DATA REDUCTION

3. A sketch of the model is shown as Figure 1. The data were obtained using a six-component internal strain-gage balance (reference (n)). These data were recorded on IBM cards using the automatic data recording system explained in reference (o)). The IBM 704 machine was used to reduce the wind-tunnel data to coefficient form. A correction was made to the data for the elastic deflection of the sting due to the aerodynamic loading.

DISCUSSION

4. Six-component data were desired over a Mach number range from 0.40 to 2.03 at angles of attack up to 70 degrees. At the supersonic Mach numbers the model size restricted the maximum angle of attack. At a Mach number of 1.53, the maximum angle of attack was 10 degrees, Mach number 1.76 the maximum angle of attack, 12 degrees, and at Mach number 2.03 the maximum angle of attack, 30 degrees.

5. The data are plotted in coefficient form versus angle of attack in Figures 2 through 37. An index of the plotted data is presented in Table I.

REFERENCES

(a) Wind-tunnel request (WTR 592) (1960)

(b) Shantz, I., and Groves, R. T., "Subsonic Damping in Pitch Measurements of the EX-10, EX-30, and 6" Test Vehicle," NAVORD Report 4025, Confidential, (1958)

(c) Long, J. E., "Free-Flight Investigation of the Stability and Drag of the EX-10 General Purpose Bomb," NAVORD Report 2916, Confidential, (1953)

(d) Long, J. E., "Low-Yaw Data on the Low Drag Bomb (EX-010) at Transonic Speeds ($0.7 \leq M \leq 1.4$)," NAVORD Report 4227, Confidential, (1956)

(e) Long, J. E., "Roll Coefficients for the Low Drag Bomb (EX-10) in the Transonic Velocity Region ($0.65 \leq M \leq 1.31$)," NAVORD Report 4389, Confidential, (1956)

(f) Gauzza, H. J., "Aeroballistic Investigation of the EX-10 Bomb at Subsonic Speeds," NAVORD Report 2814, Confidential, (1953)

(g) Greene, J. E., "Static Stability and Magnus Characteristics of a Low Drag Bomb at Low Subsonic Speeds," NAVORD Report 4112, Confidential, (1956)

(h) Greene, J. E., "Static Stability and Magnus Characteristics of the U. S. Navy 1000 Pound Low Drag Bomb at Transonic Speeds," NAVORD Report 4329, Confidential, (1957)

(i) Piper, W. D., "Static Stability Characteristics of the EX-10 Low Drag Bomb," NAVORD Report 4503, Confidential, (1958)

(j) Crogan, L. E., "Drag and Roll Coefficients at Subsonic to Supersonic Velocities of 1/7-Scale Free-Flight Models of the 1000 Pound Low Drag Bomb (EX-10)," NAVORD Report 6661, Unclassified

(k) DeMeritte, F. J., Gauzza, H., "Wind-Tunnel Investigation of Various Configurational Modifications of the Low Drag Bomb," NAVORD Report 4053, Confidential, (1959)

(l) DeMeritte, F. J., Gauzza, H., Shantz, I., "Miscellaneous Wind-Tunnel Tests on the Low Drag Bomb," NAVORD Report 5702, Unclassified, (1959)

(m) Piper, W. D., DeMeritte, F. J., "Summary of the NOL Investigations to Date of the Aerodynamic Characteristics of the Navy Low Drag Bomb," NAVORD Report 5679, Confidential, (1960)

(n) Shantz, I., Gilbert, B. D., and White, C. E., "NOL Wind-Tunnel Internal Strain-Gage Balance System," NAVORD Report 2972, Unclassified, (1953)

(o) Gilbert, B. D., "Automatic Data Processing System (ADAPS) for the Supersonic Wind Tunnels," NAVORD Report 2813, Unclassified, (1953)

TABLE I

INDEX OF PLOTTED DATA

Figure No.	Run Number	Mach No.	ϕ deg	α deg	Coefficients Plotted
2	8	1.53	-45	0-10	C_N, C_Θ, C_Y, C_ψ
3	8	1.53	-45	0-10	C_ϕ, C_A
4	9	1.53	-22.5	0-10	C_N, C_Θ, C_Y, C_ψ
5	9	1.53	-22.5	0-10	C_ϕ, C_A
6	10	1.53	0	0-10	C_N, C_Θ, C_Y, C_ψ
7	10	1.53	0	0-10	C_ϕ, C_A
8	7	1.76	-45	0-12	C_N, C_Θ, C_Y, C_ψ
9	7	1.76	-45	0-12	C_ϕ, C_A
10	6	1.76	-22.5	0-12	C_N, C_Θ, C_Y, C_ψ
11	6	1.76	-22.5	0-12	C_ϕ, C_A
12	5	1.76	0	0-12	C_N, C_Θ, C_Y, C_ψ
13	5	1.76	0	0-12	C_ϕ, C_A
14	18,20,21	0.40	-45	0-70	C_N, C_Θ, C_Y, C_ψ
15	18,20,21	0.40	-45	0-70	C_ϕ, C_A
16	19,22	0.40	-22.5	0-70	C_N, C_Θ, C_Y, C_ψ
17	19,22	0.40	-22.5	0-70	C_ϕ, C_A
18	23	0.40	0	30-70	C_N, C_Θ, C_Y, C_ψ

TABLE I (Cont.d)

Figure No.	Run Number	Mach No.	ϕ deg	α deg	Coefficients Plotted
19	23	0.40	0	30-70	C_ϕ, C_A
20	17,27,34	0.60	-45	0-70	C_N, C_θ, C_Y, C_ψ
21	17,27,34	0.60	-45	0-70	C_ϕ, C_A
22	16,26	0.60	-22.5	0-70	C_N, C_θ, C_Y, C_ψ
23	16,26	0.60	-22.5	0-70	C_ϕ, C_A
24	15,24,25, 33	0.60	0	0-70	C_N, C_θ, C_Y, C_ψ
25	15,24,25 33	0.60	0	0-70	C_ϕ, C_A
26	28,31	0.80	-45	29-70	C_N, C_θ, C_Y, C_ψ
27	28,31	0.80	-45	29-70	C_ϕ, C_A
28	12,29	0.80	-22.5	0-70	C_N, C_θ, C_Y, C_ψ
29	12,29	0.80	-22.5	0-70	C_ϕ, C_A
30	11,13,14, 30,32	0.80	0	0-70	C_N, C_θ, C_Y, C_ψ
31	11,13,14, 30,32	0.80	0	0-70	C_ϕ, C_A
32	1,2	2.03	-45	-6-30	C_N, C_θ, C_Y, C_ψ
33	1,2	2.03	-45	-6-30	C_ϕ, C_A
34	3	2.03	-22.5	-0-30	C_N, C_θ, C_Y, C_ψ
35	3	2.03	-22.5	-0-30	C_ϕ, C_A
36	4	2.03	0	-0-30	C_N, C_θ, C_Y, C_ψ
37	4	2.03	0	-0-30	C_ϕ, C_A

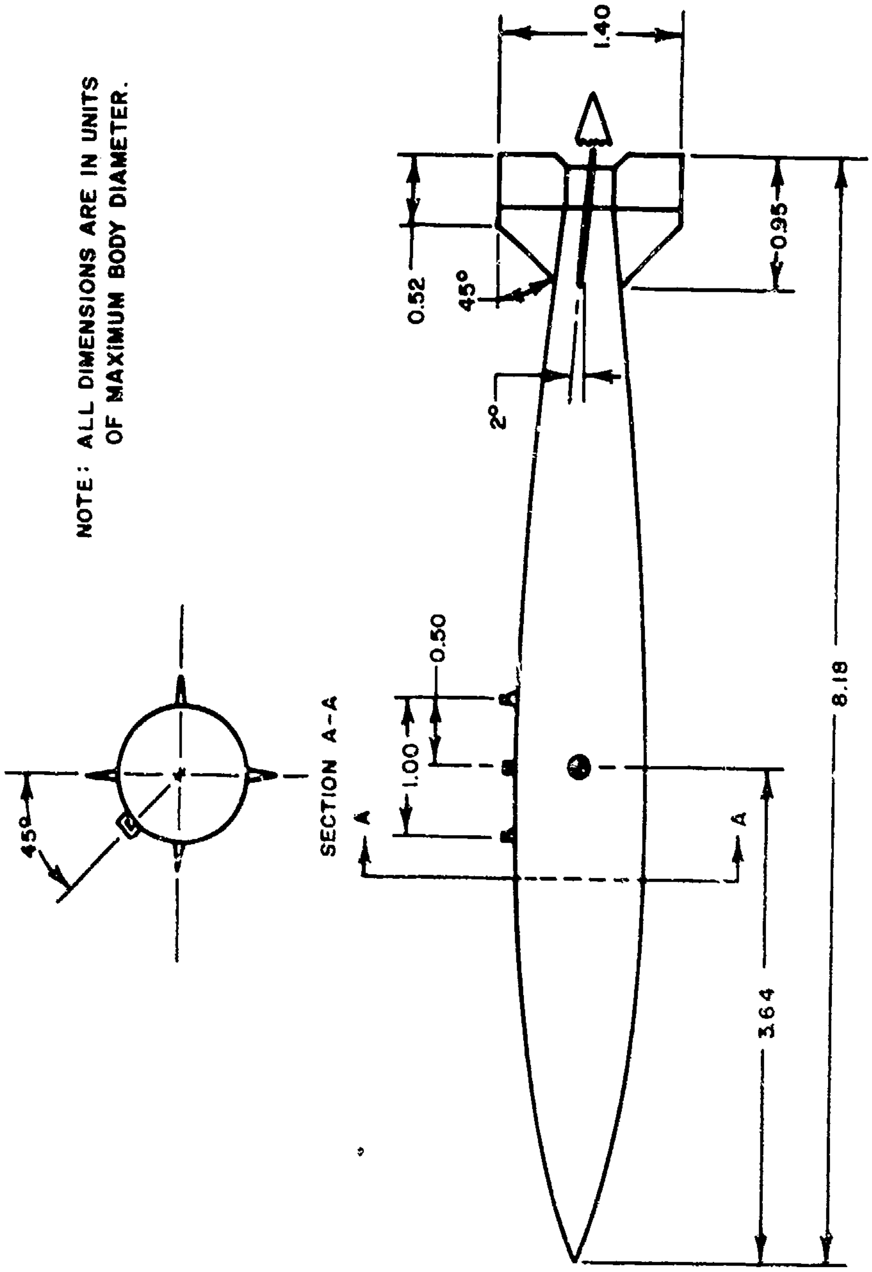


FIG.1 U.S. NAVY GENERAL PURPOSE LOW DRAG BOMB

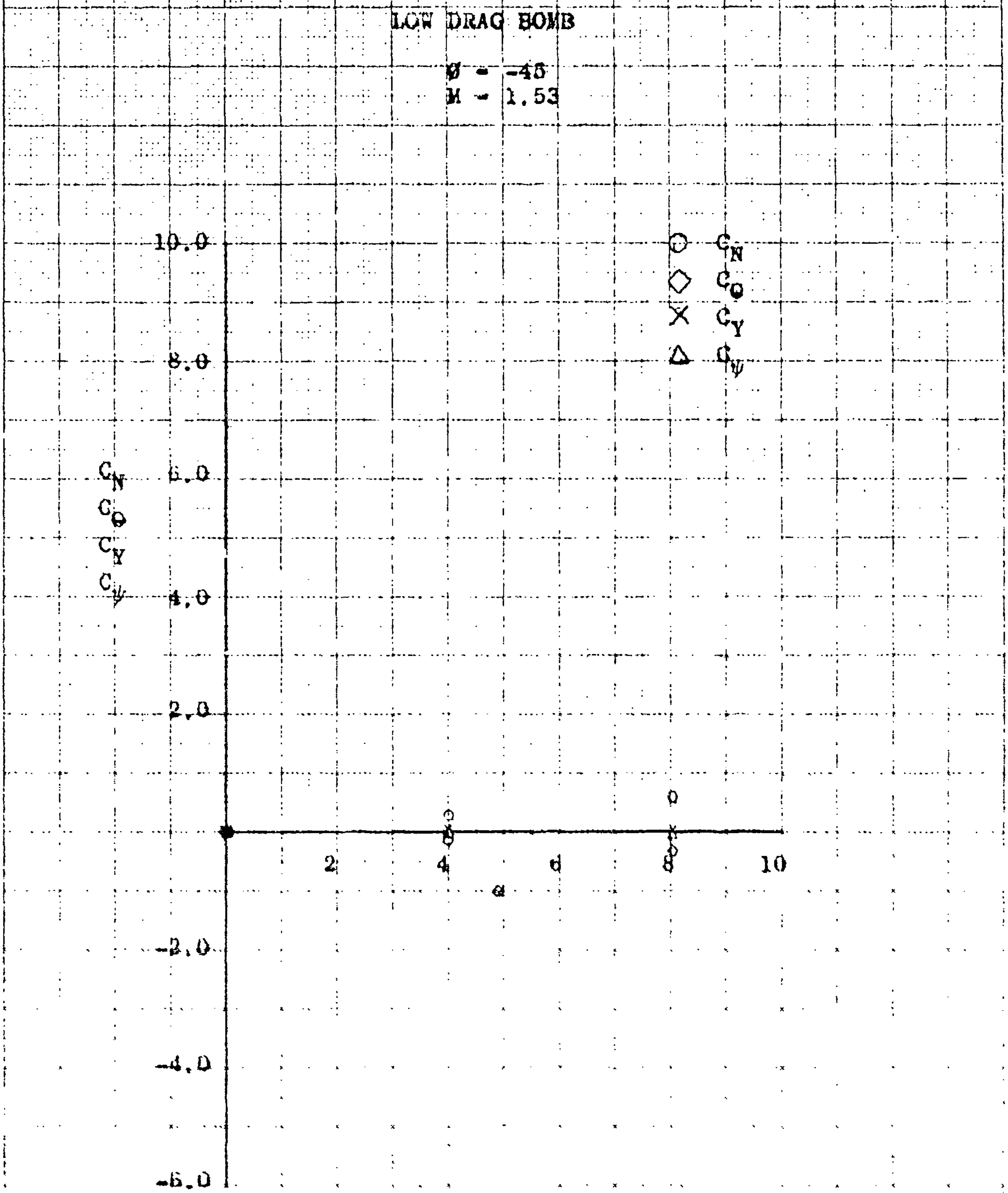


FIG. 2 C_N, C_Q, C_Y, C_ψ vs. α

LOW DRAG BOMB

$\phi = -45$
$M = 1.53$

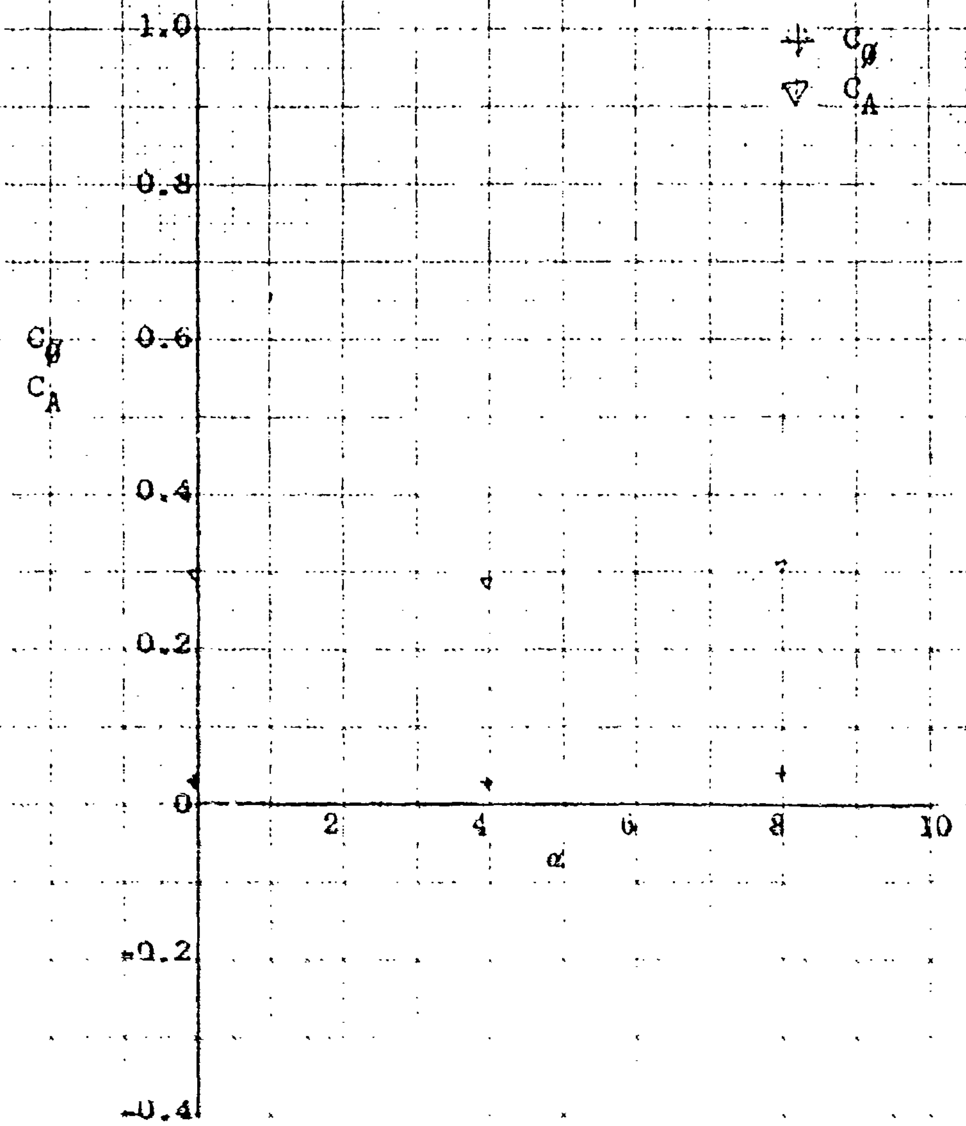


FIG. 3 C_ϕ, C_A vs. α

LOW FRAG BOMB

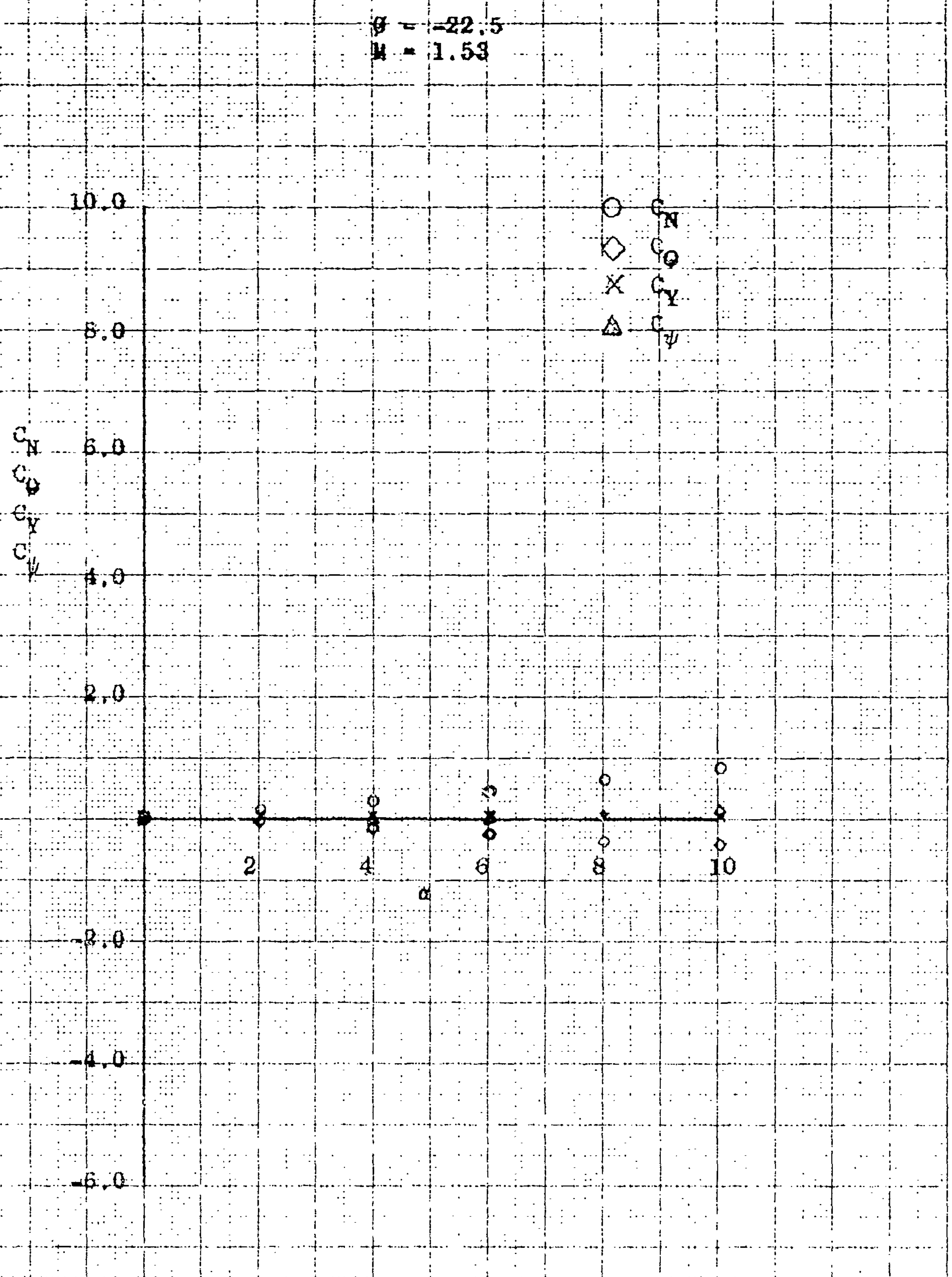


FIG. 4 C_N, C_Q, C_Y, C_ψ vs. α

LOW DRAG BOMB

$\phi = 0$
$M = 1.53$

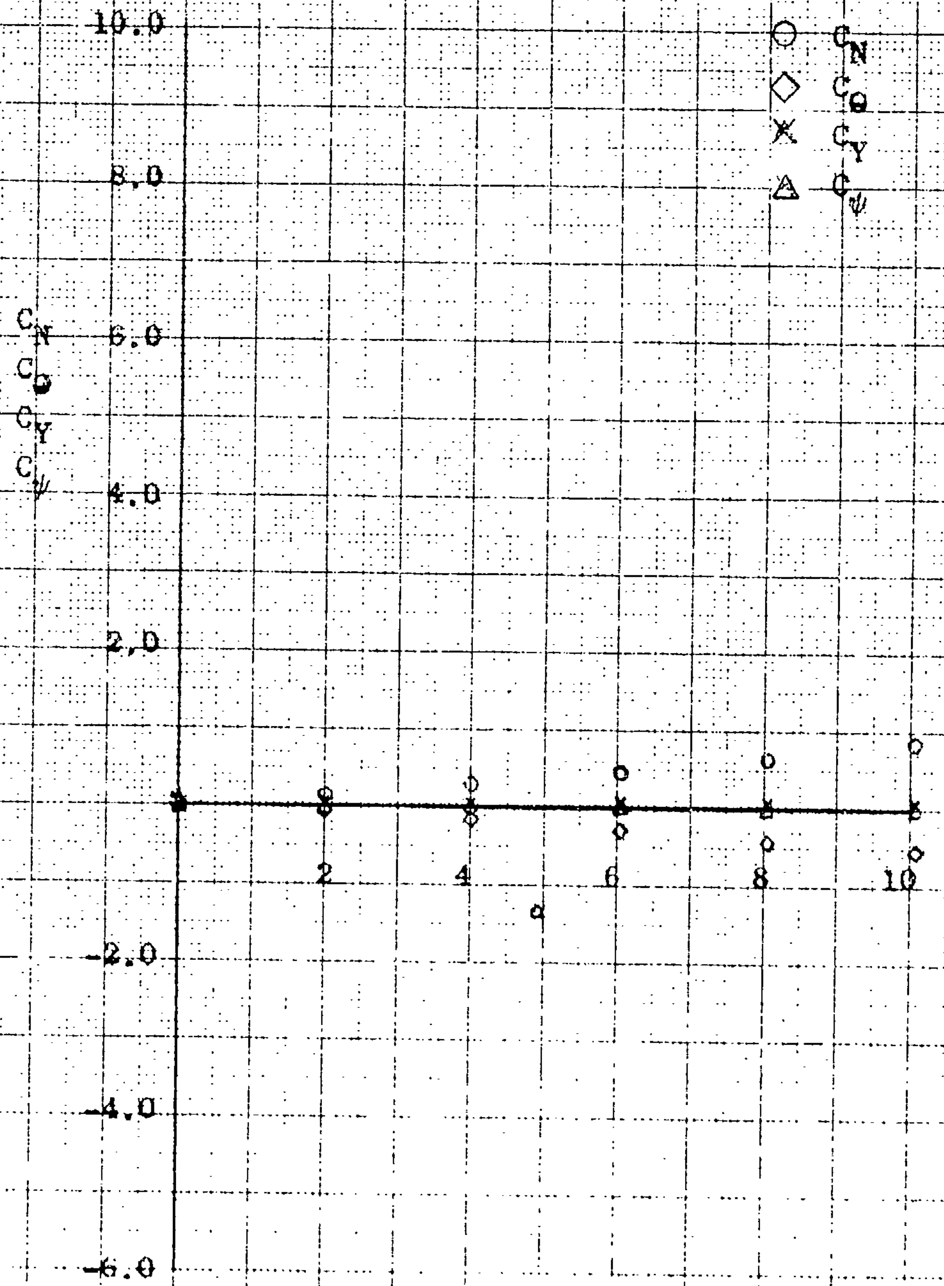


FIG. 6 C_N, C_θ, C_Y, C_ψ vs. α

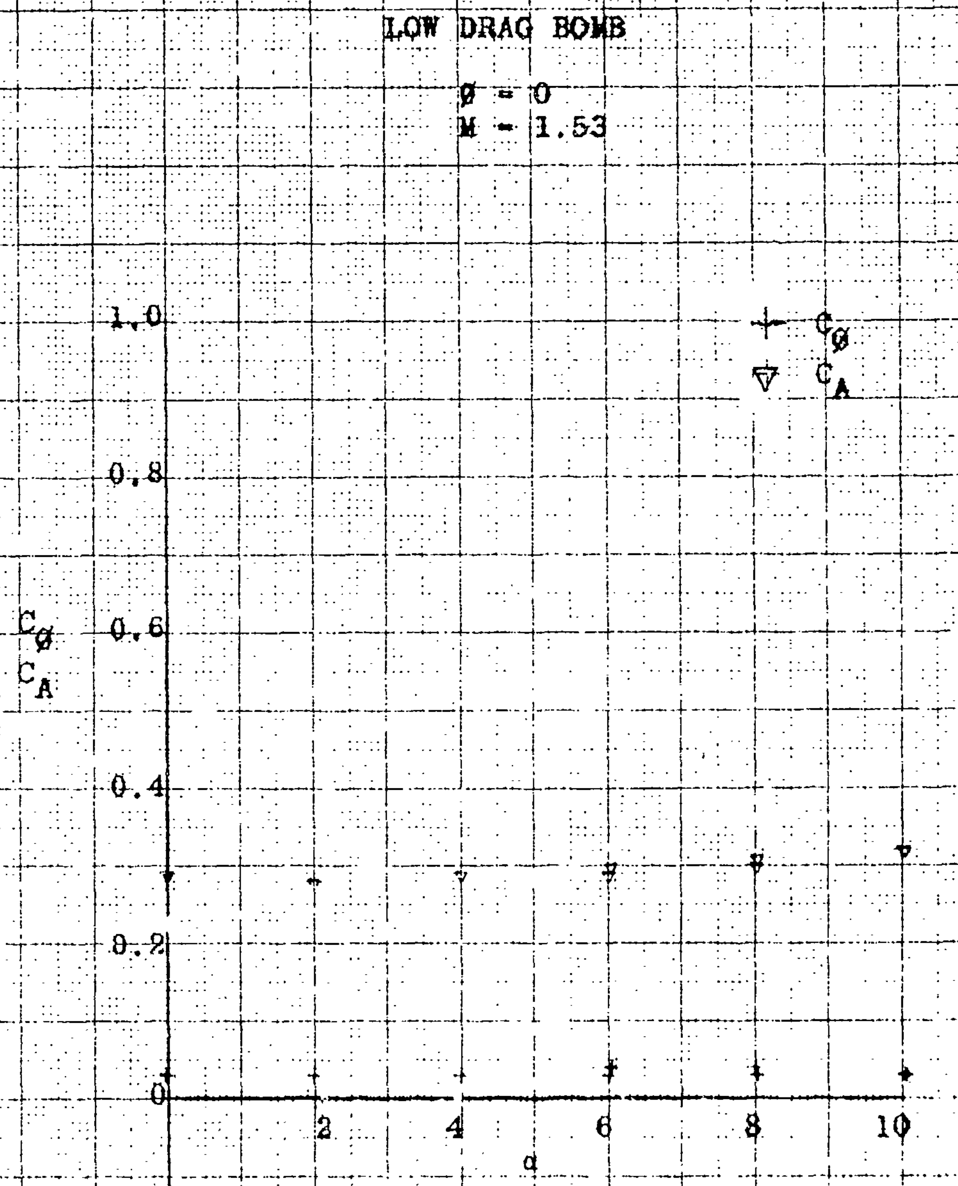


FIG. 7 $C_ø$, C_A vs. α

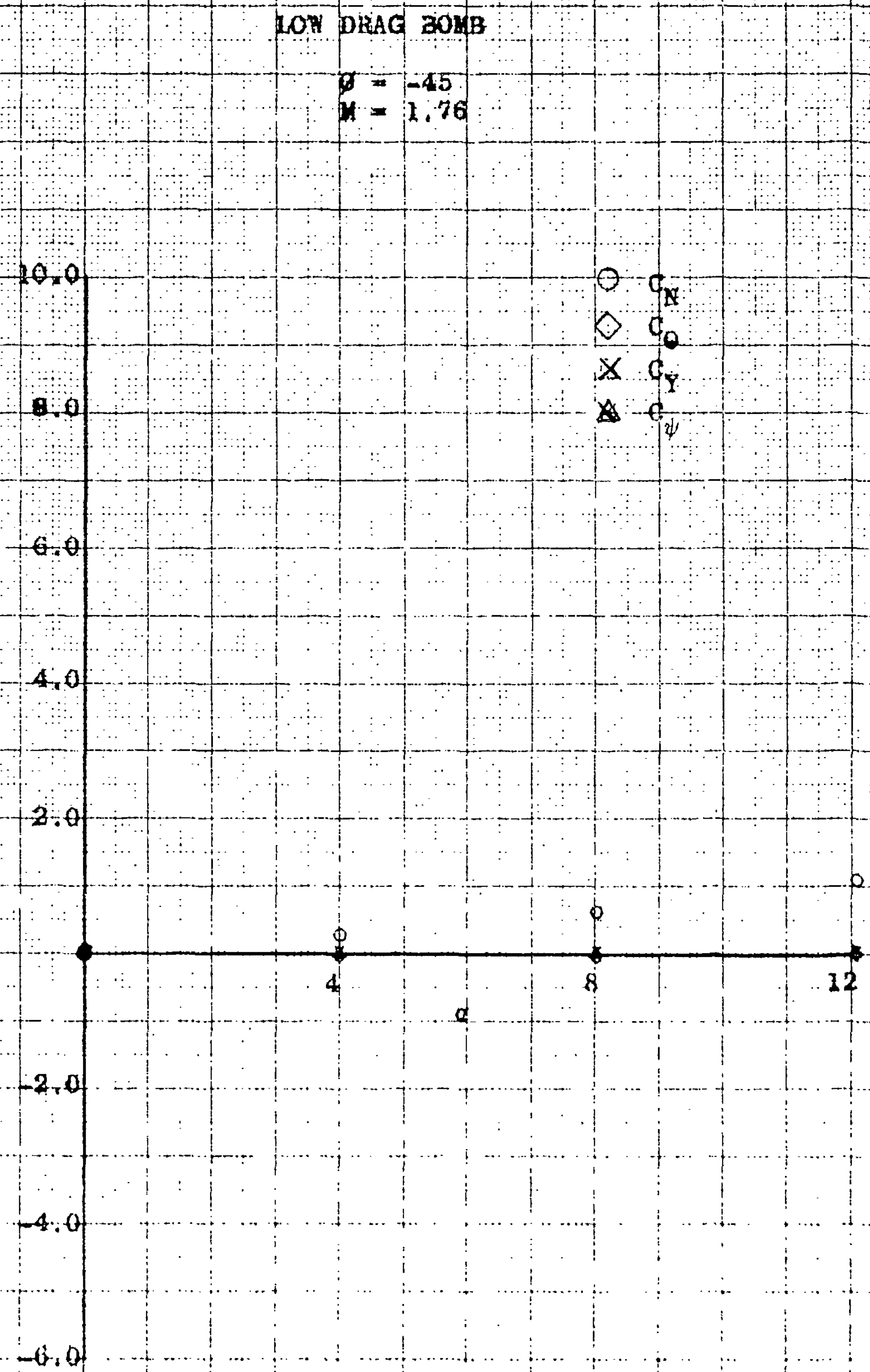


FIG. 8 C_N, C_Q, C_Y, C_ψ vs. α

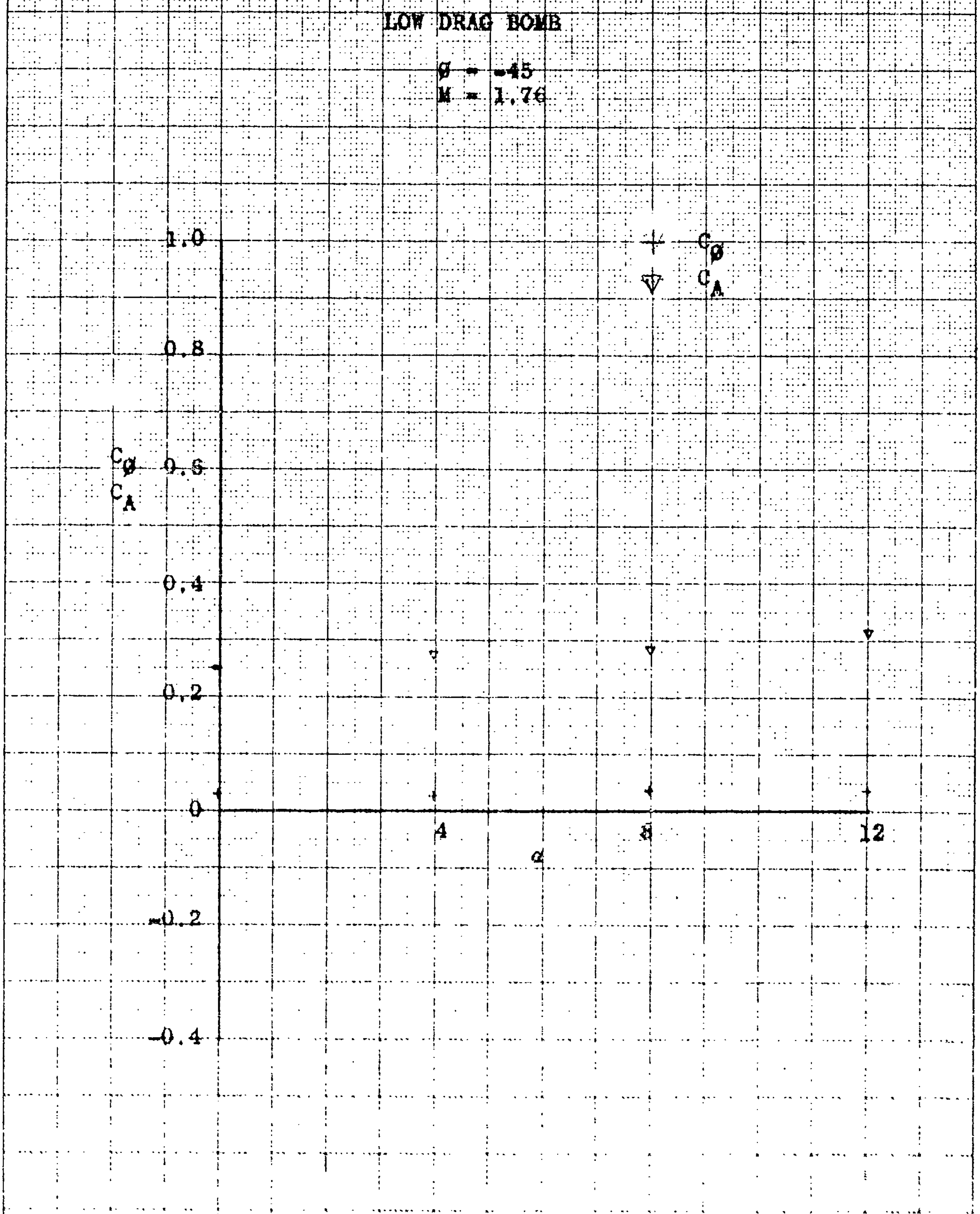


FIG. 9 $C_Ø$, C_A vs. α

LOW DRAG BOMB

$\phi = -22.5$
$M = 1.76$

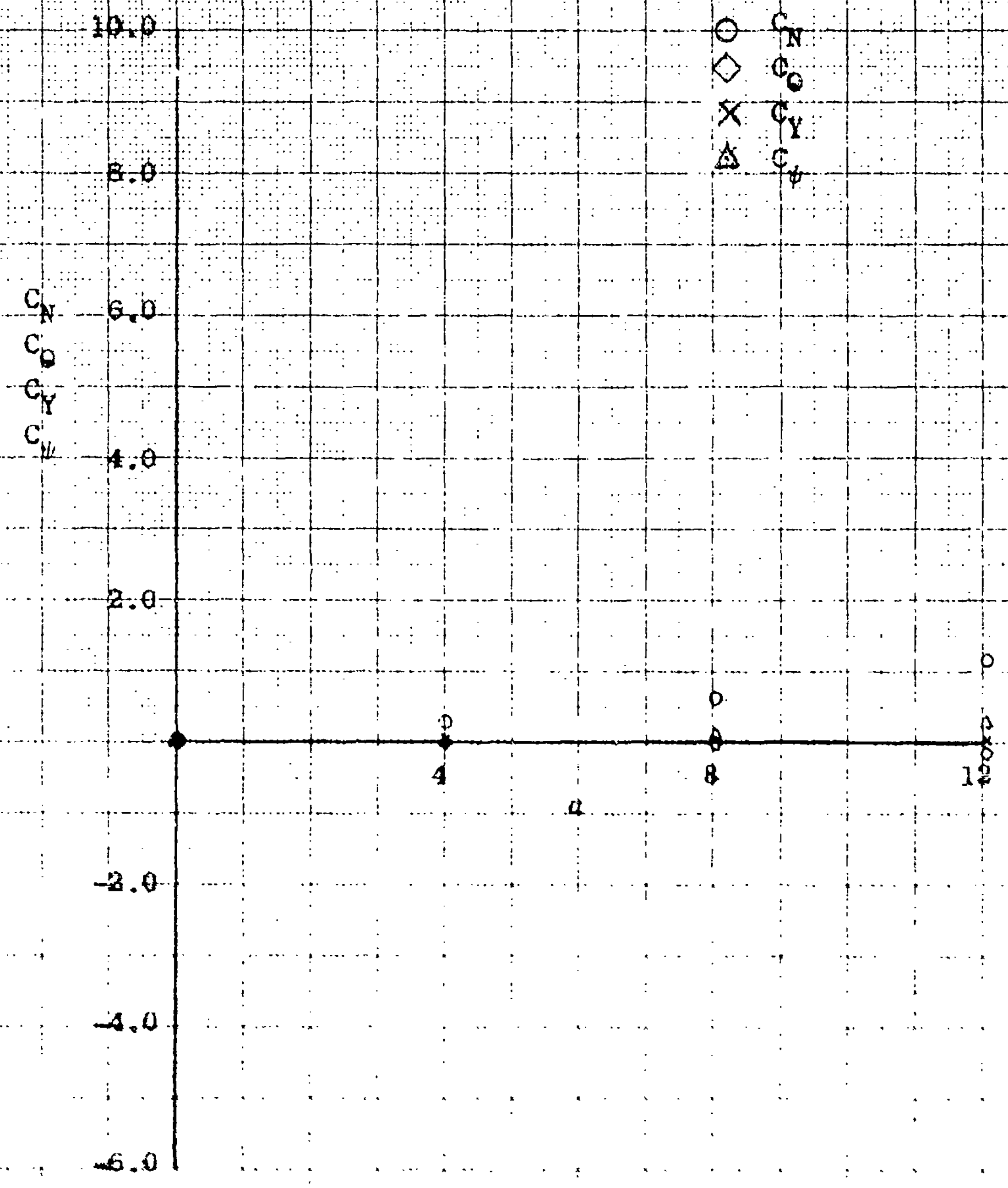


FIG. 10 C_N, C_Q, C_Y, C_ψ VS. α

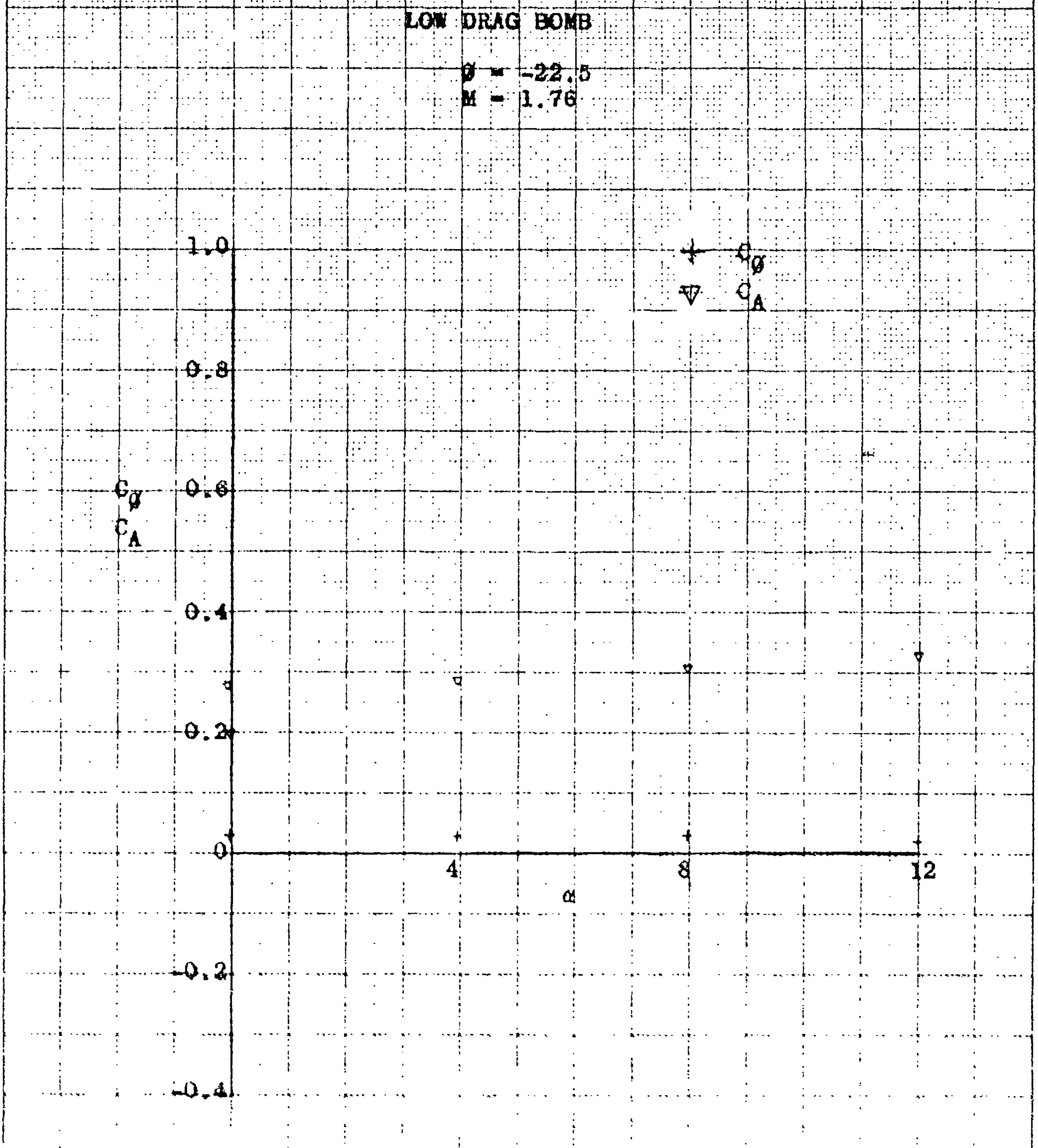


FIG. 11 C_ϕ, C_A vs. α

LOW DRAG BOMB

$\phi = 0$
$M = 1.76$

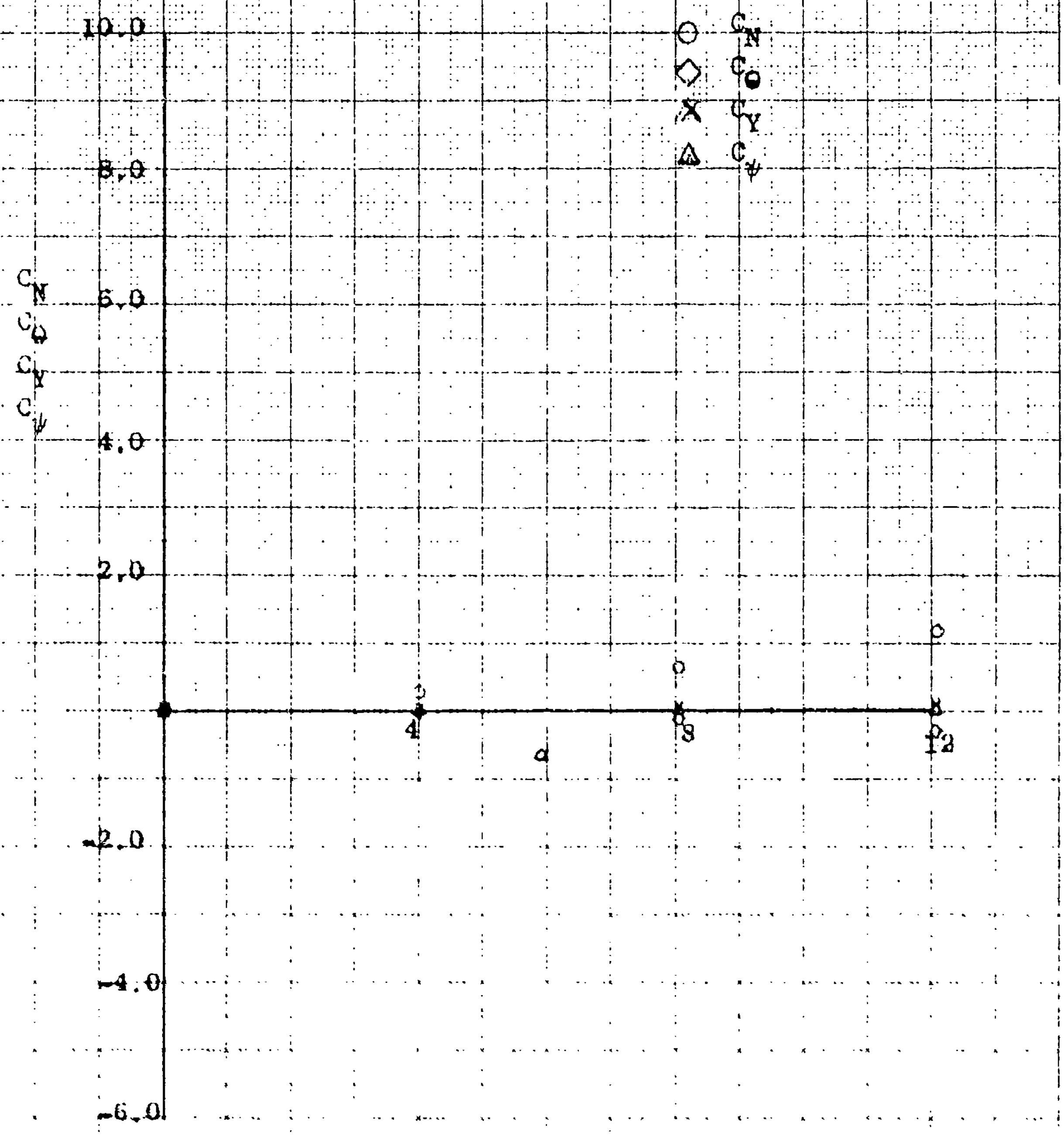


FIG. 12 C_N, C_Θ, C_Y, C_ψ vs. α

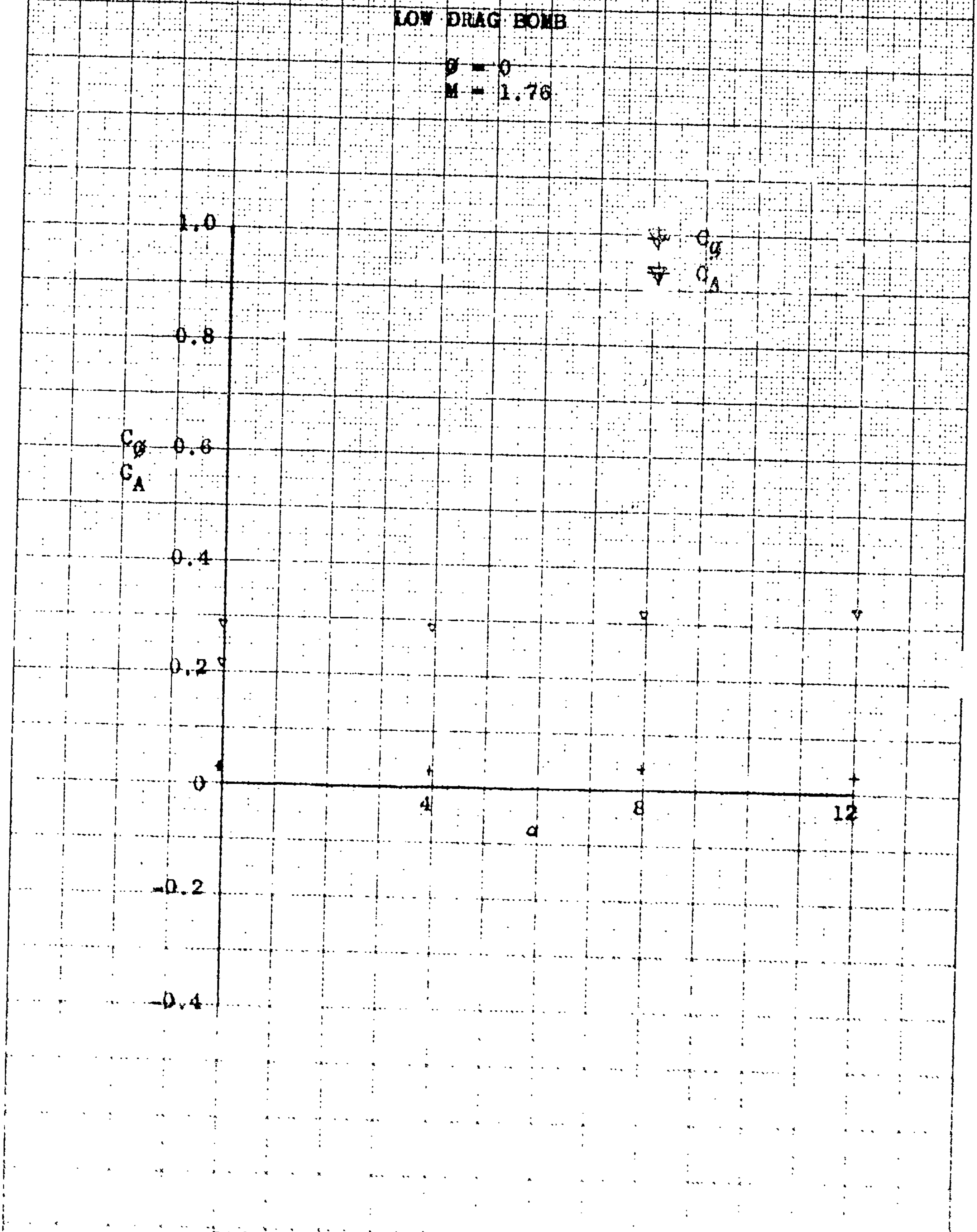


FIG. 13 $C_Ø$, C_A vs. α

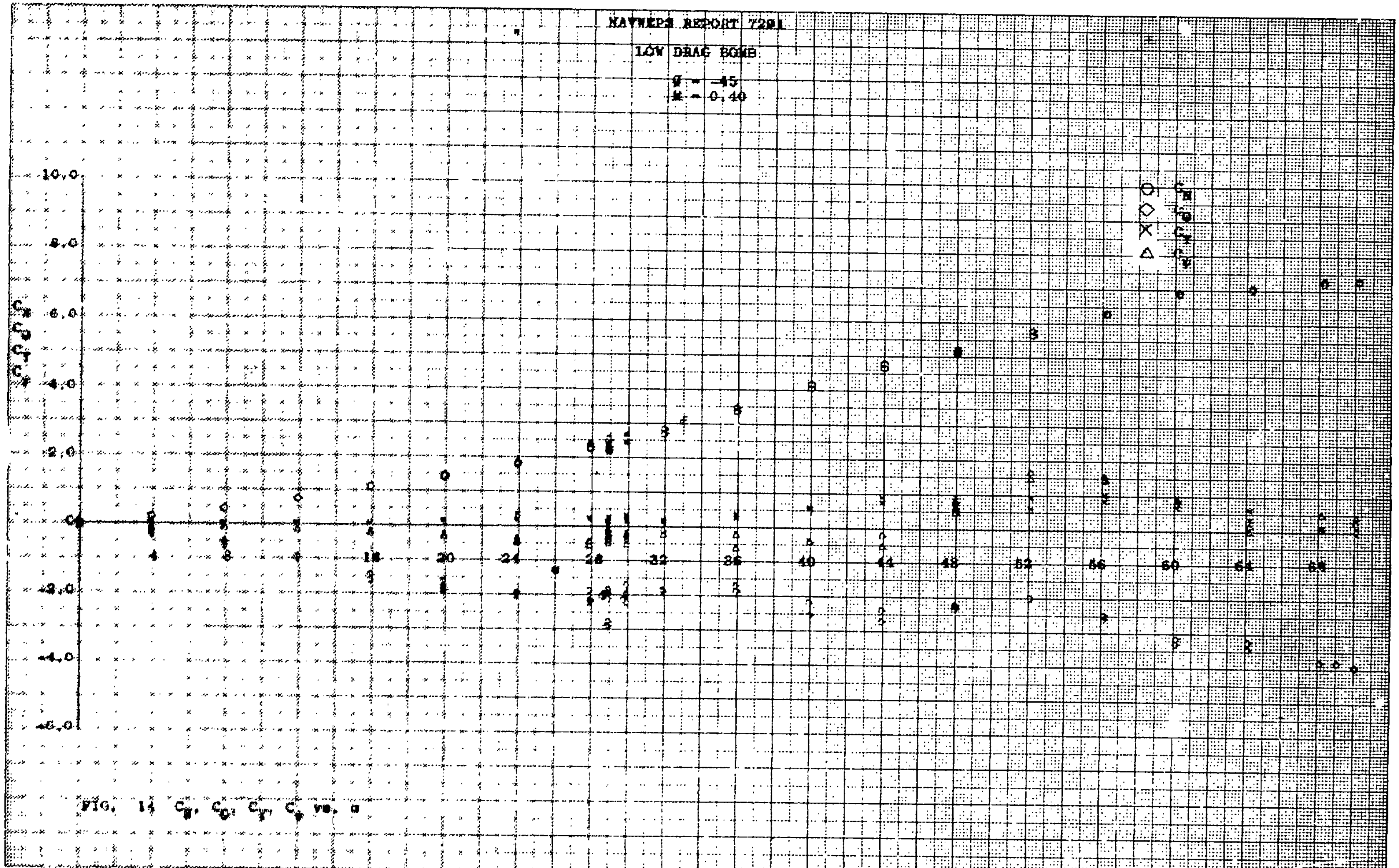


FIG. 14 C_N, C_D, C_Y, C_ψ vs. α

LOW DRAG BOMB

$\phi = 45$
$M = 0.40$

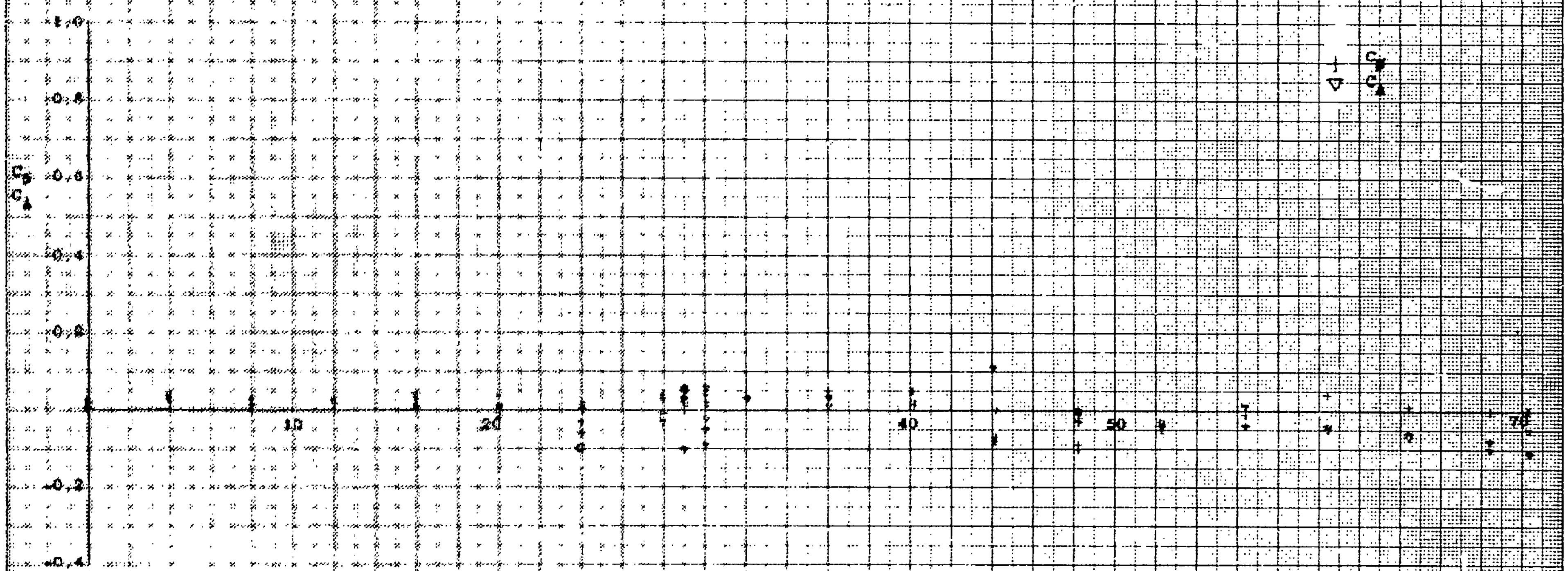


FIG. 15 C_ϕ, C_λ vs. α

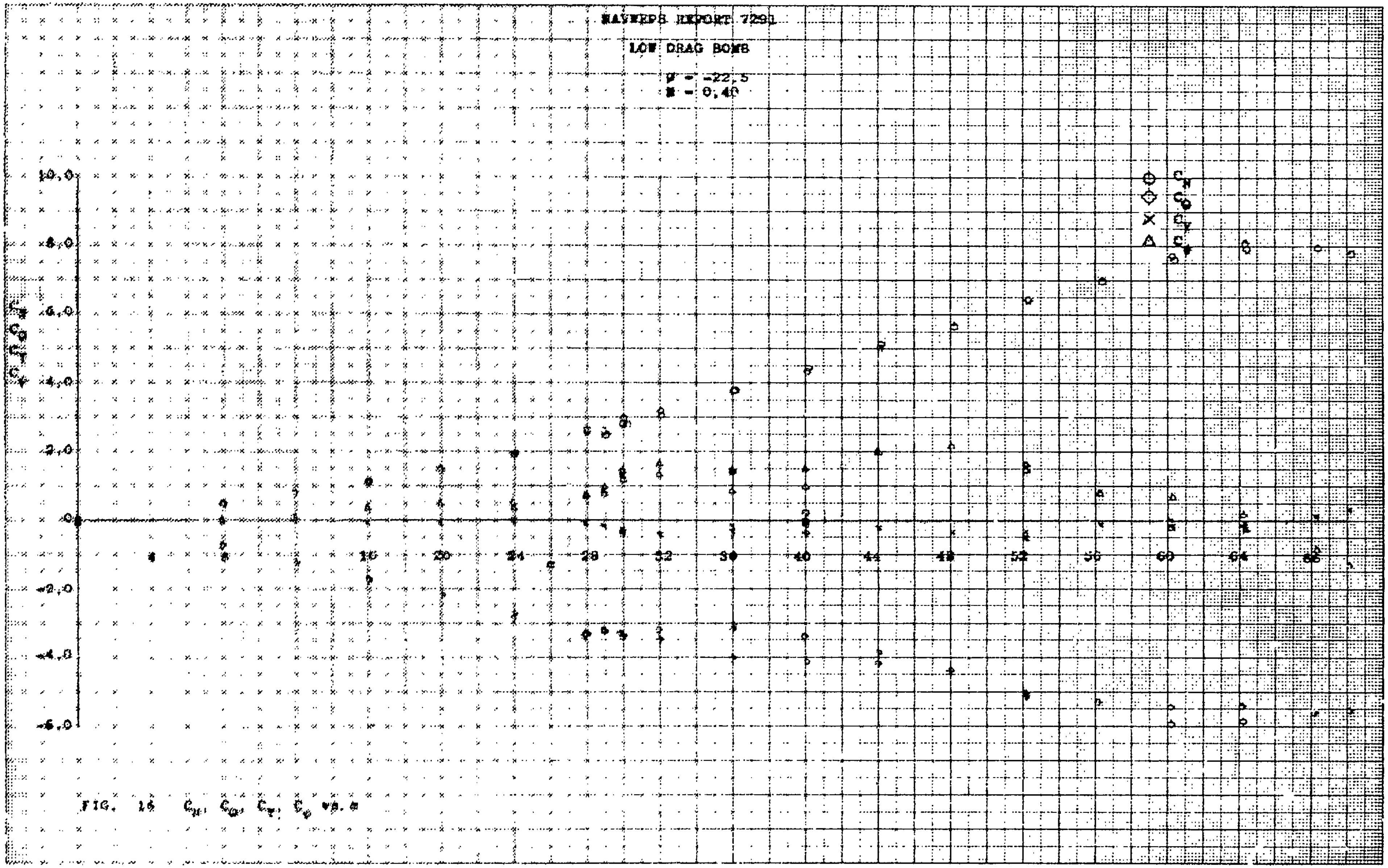


FIG. 16 C_N, C_m, C_Y, C_n vs. α

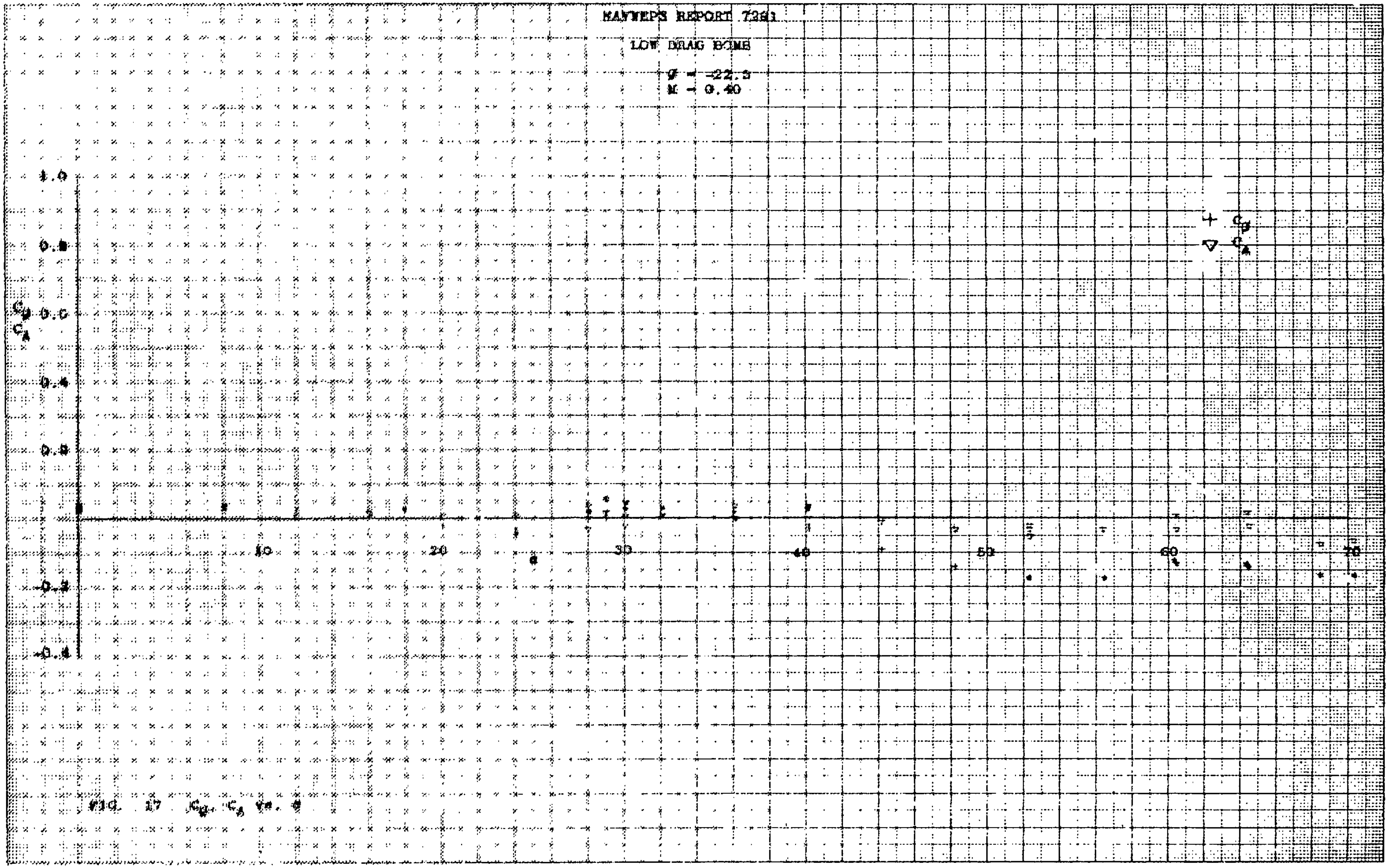


FIG. 17 C_ϕ, C_A vs. α

4

LOW DRAG BOMB

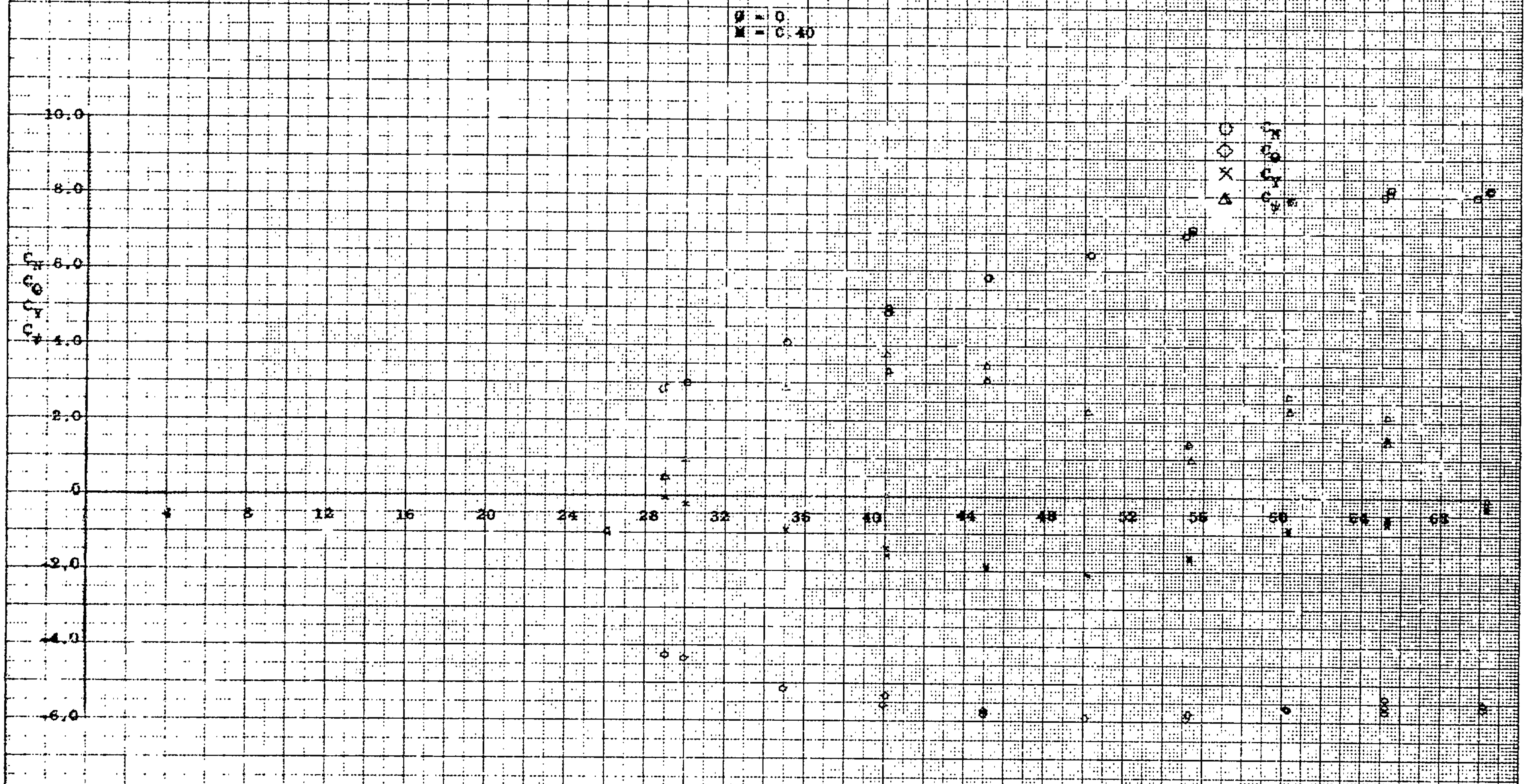


FIG. 18 C_N, C_Q, C_Y, C_ψ VS. α

Fig 6

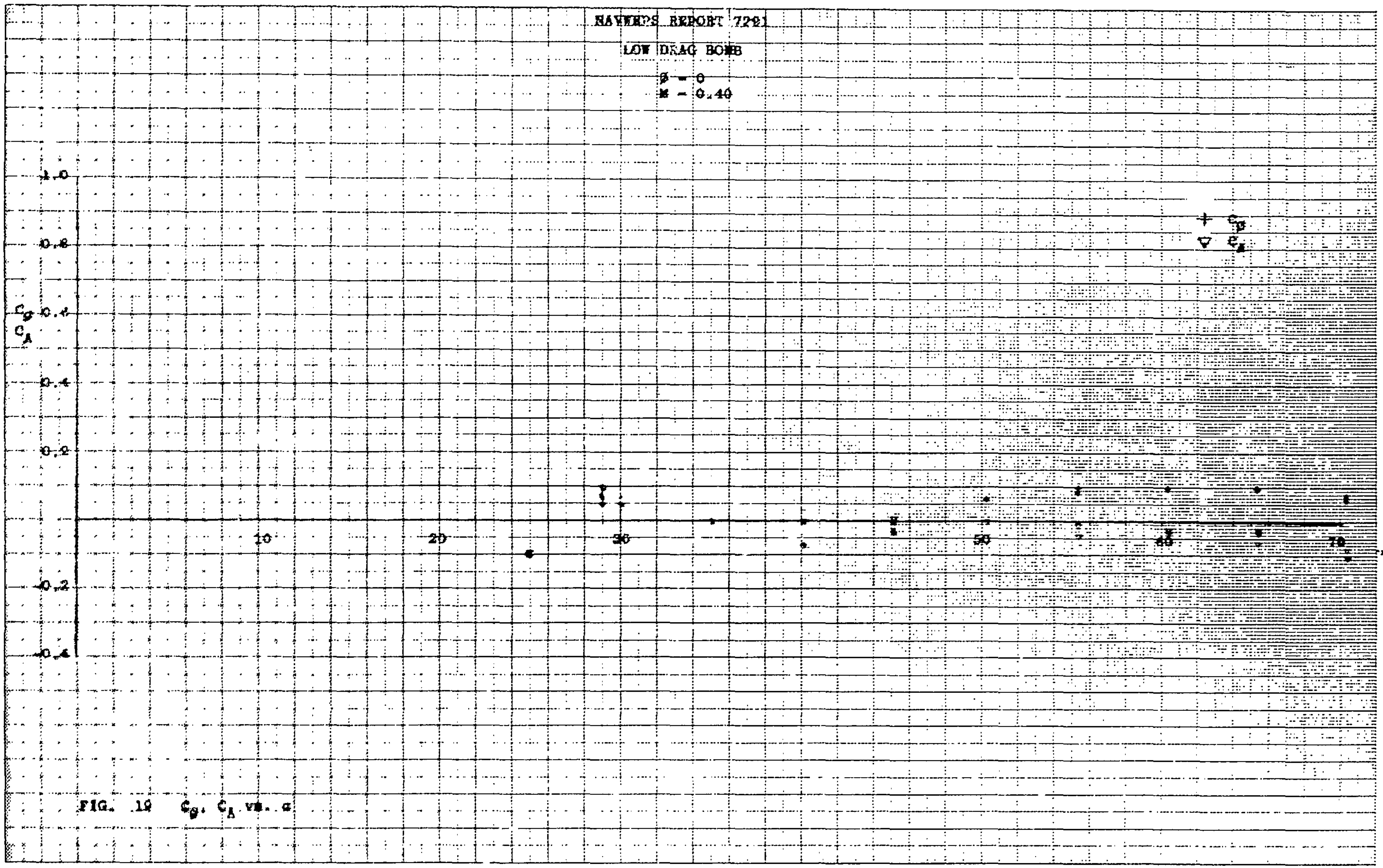


FIG. 19 C_ϕ, C_A vs. α

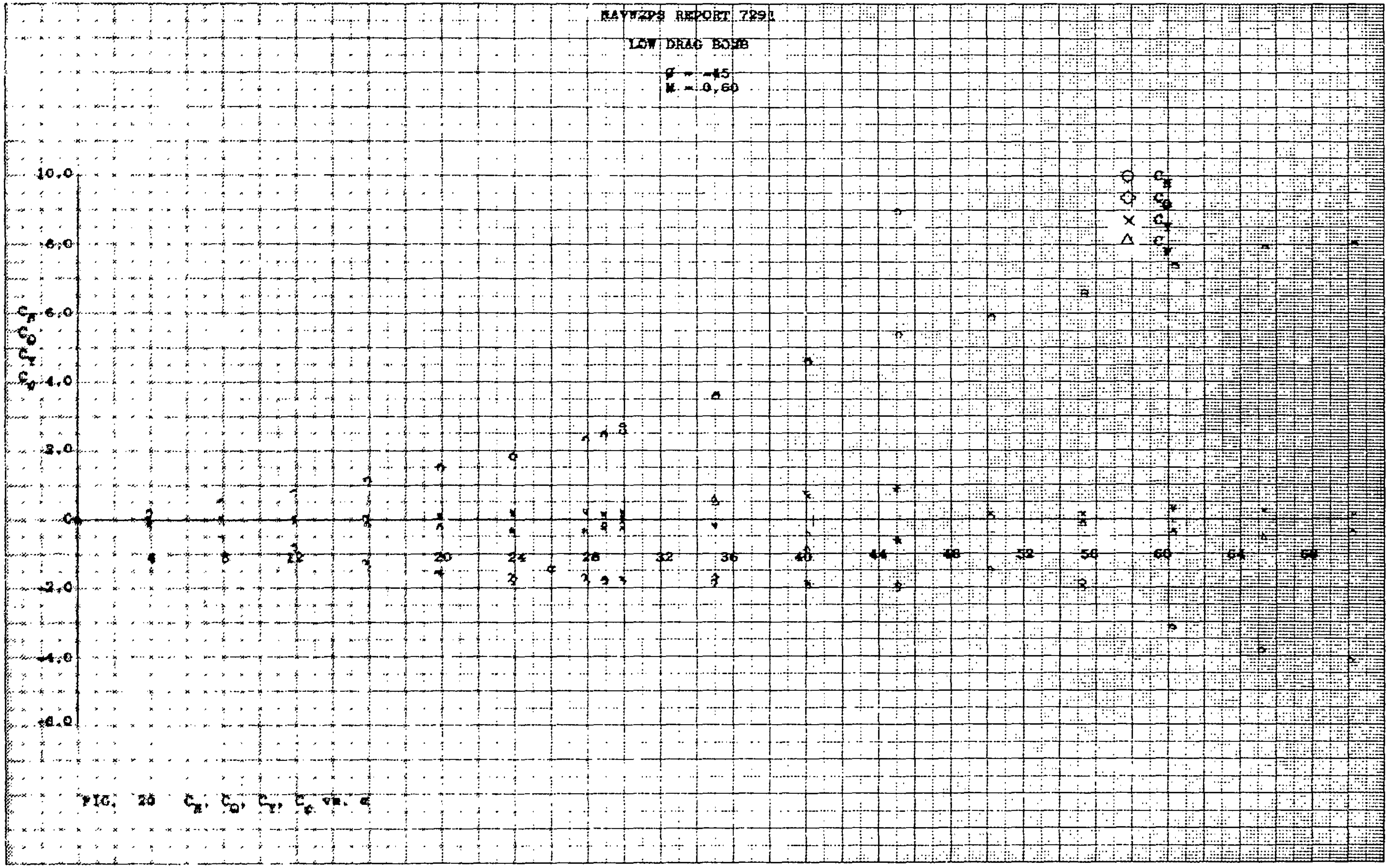


FIG. 26 C_N, C_Q, C_Y, C_ψ vs. α

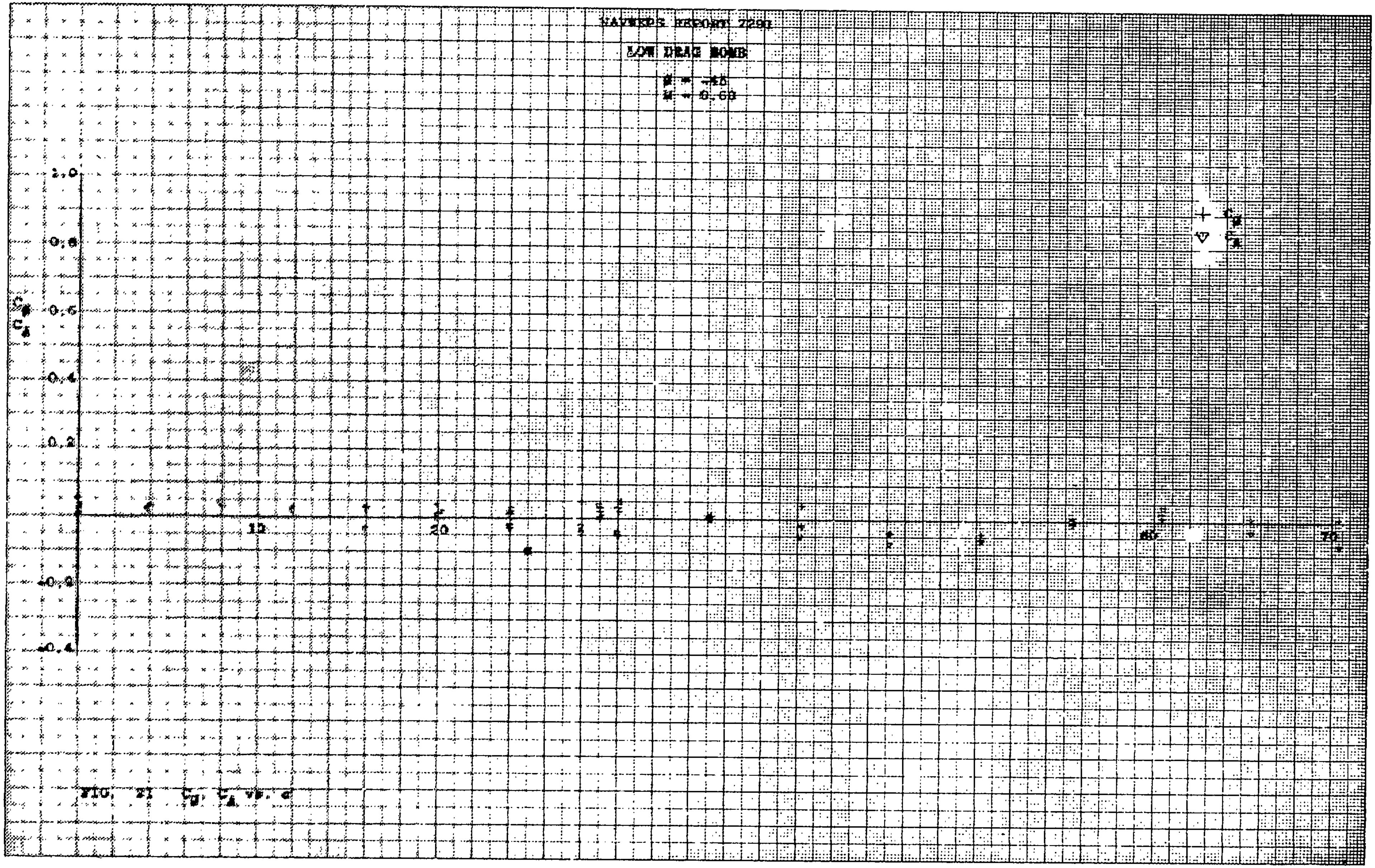


FIG. 21 C_N, C_A vs. α

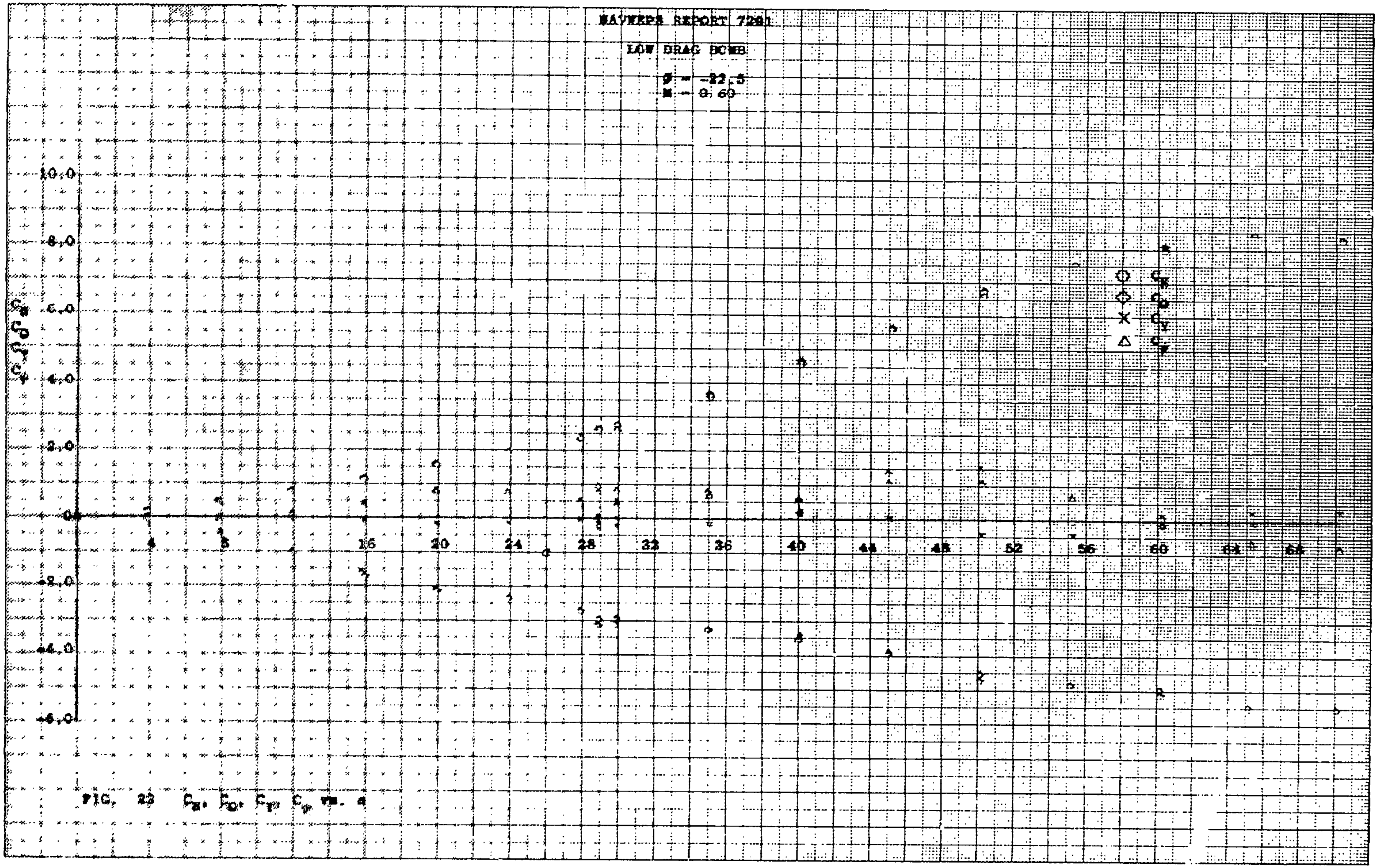
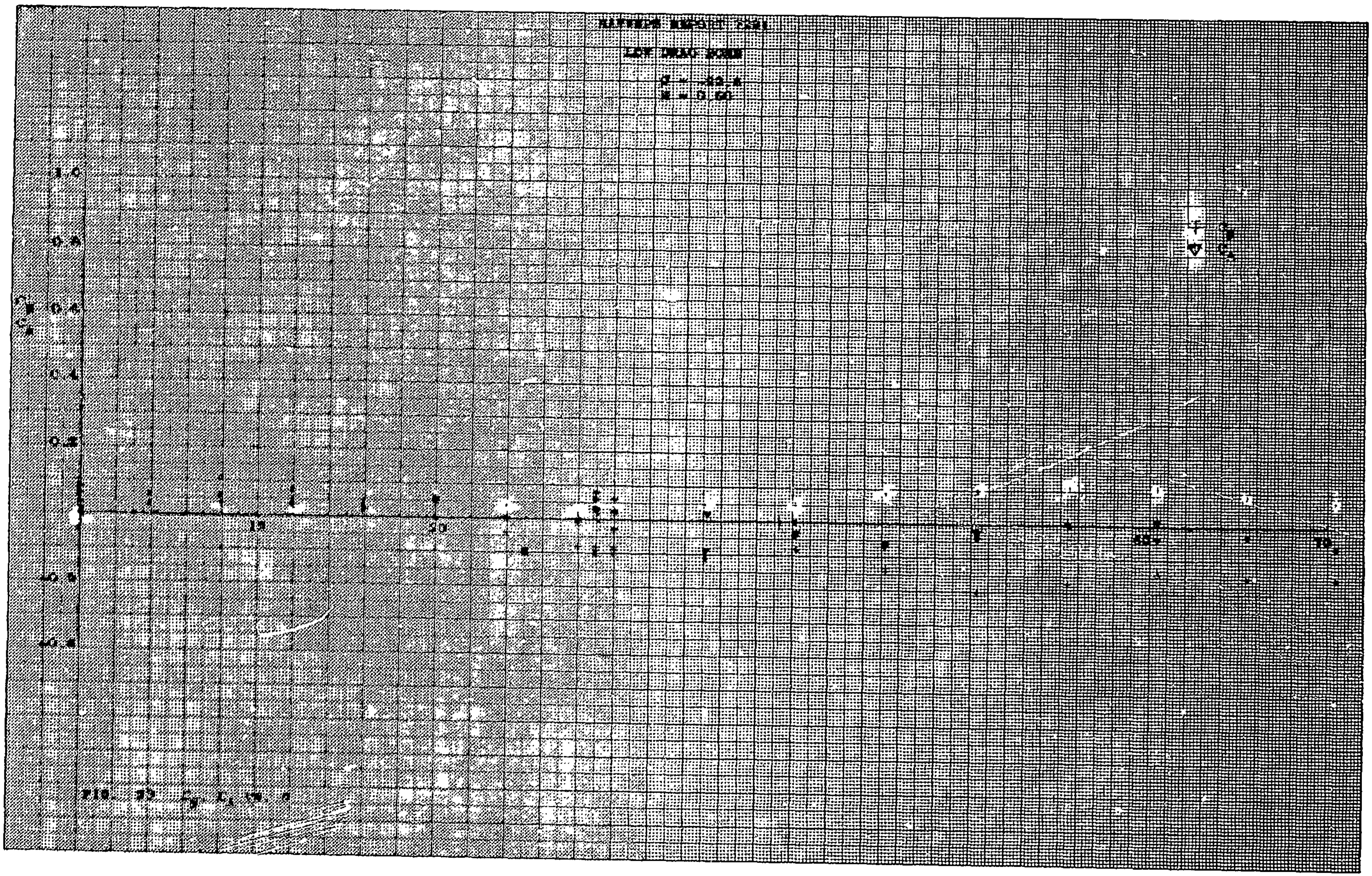


FIG. 23 C_N, C_D, C_Y, C_ψ vs. α


LOW DRAG BOMB
M = 0.60
1.0
0.8
0.6
0.4
0.2
-0.2
-0.4
10
20
60
70

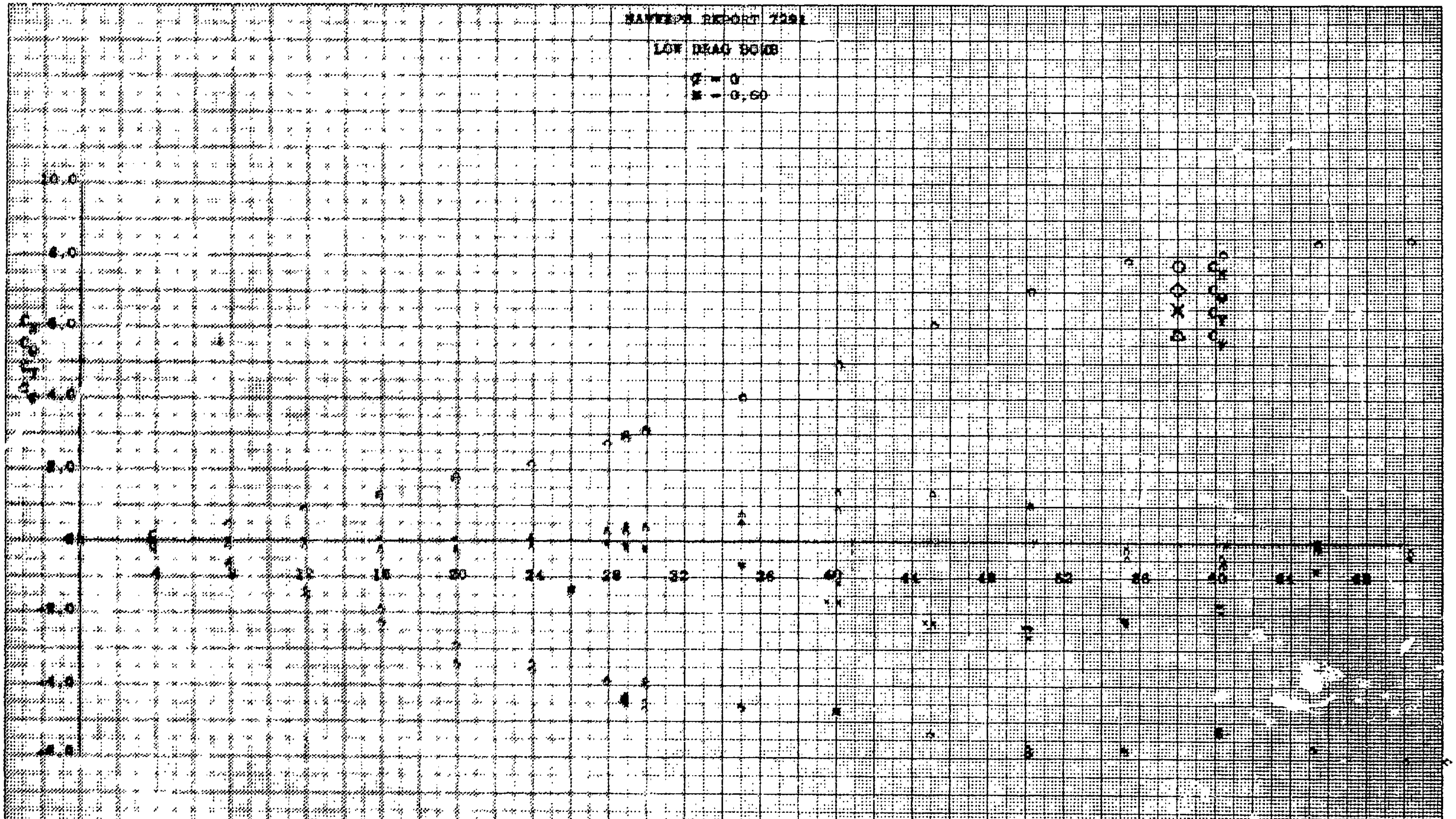


FIG. 26 C_N, C_m, C_Y, C_n vs. α

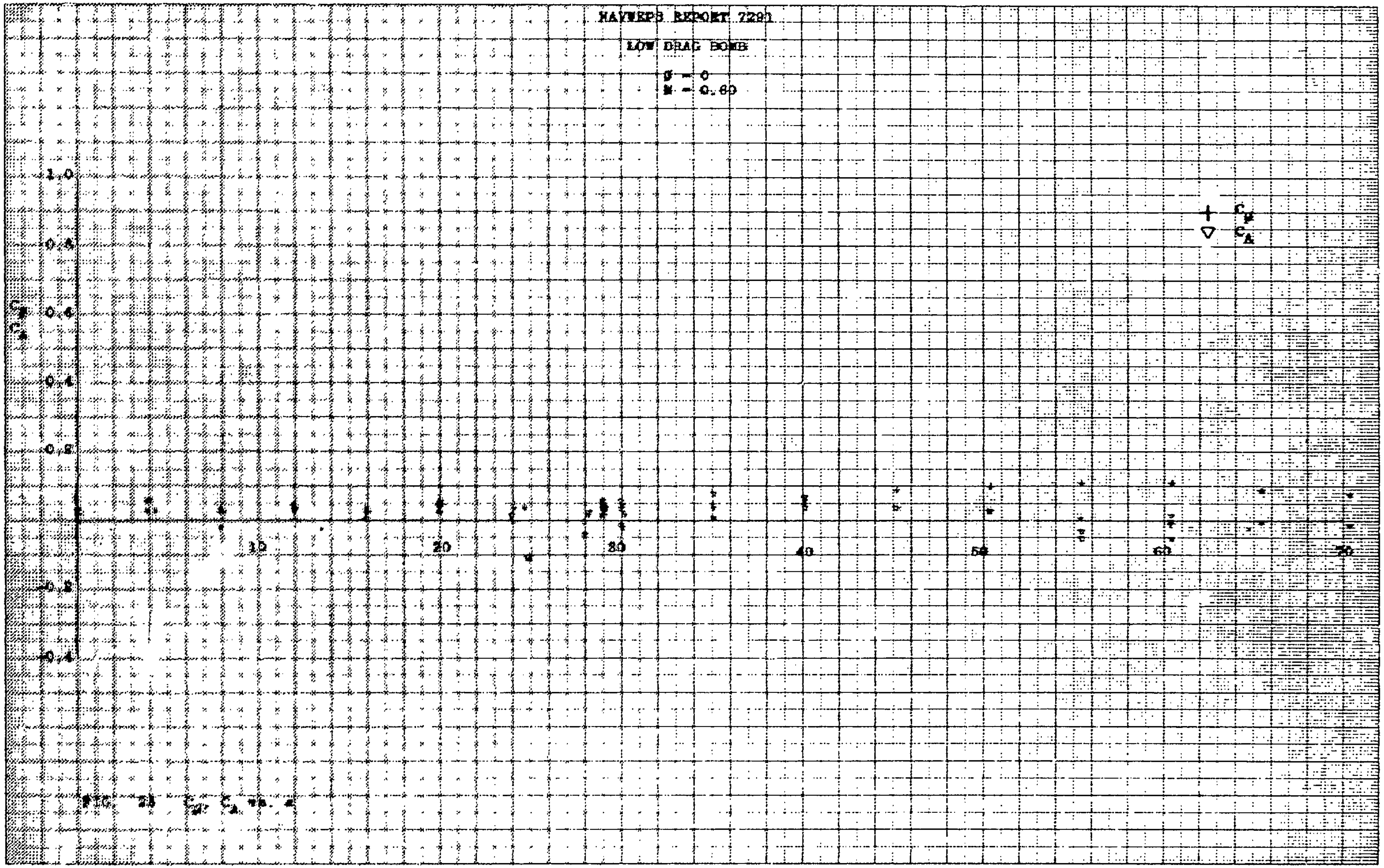


FIG. 23 C_ψ, C_A vs. α

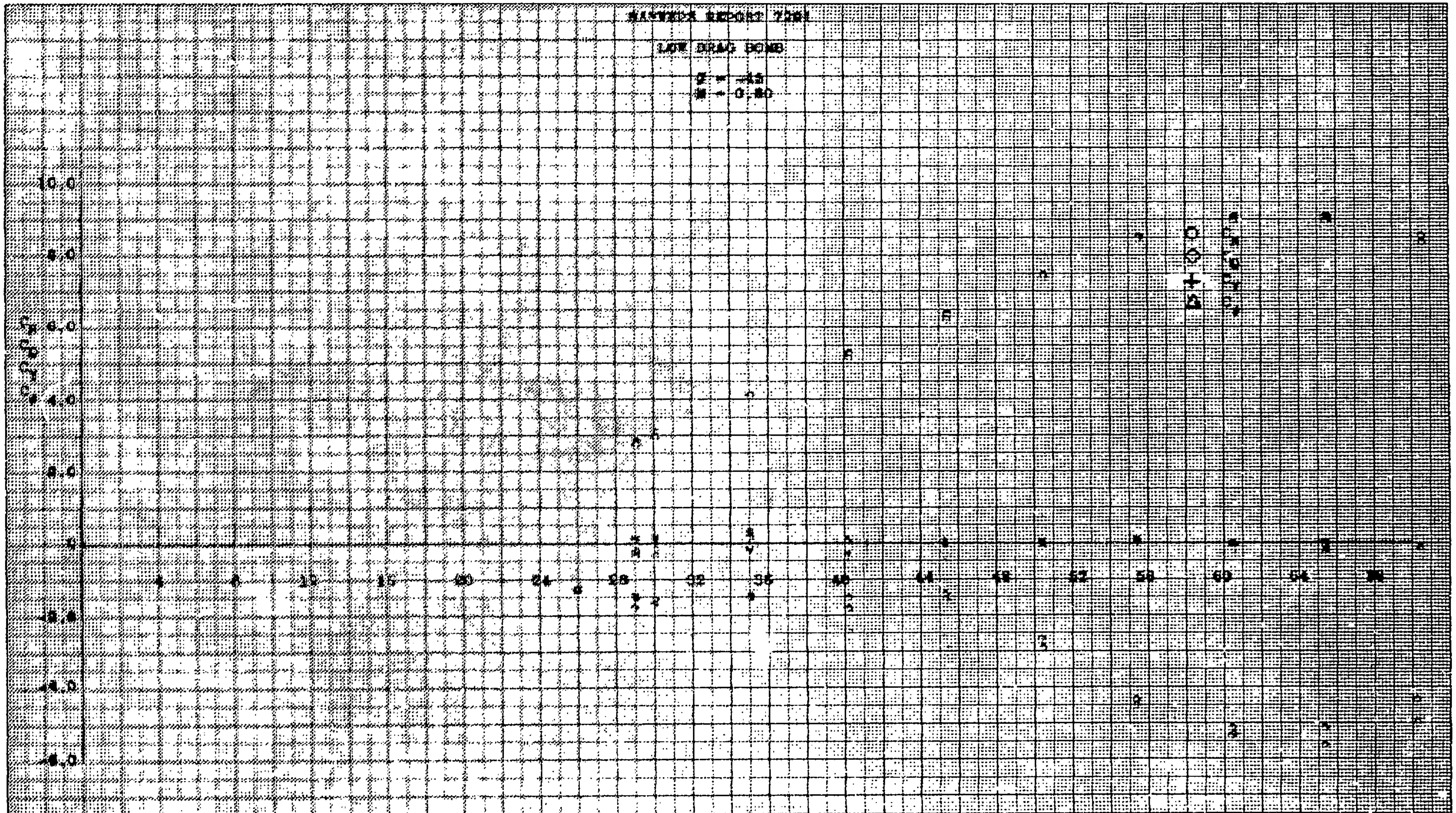


FIG. 18 C_N, C_D, C_Y, C_ℓ vs. α

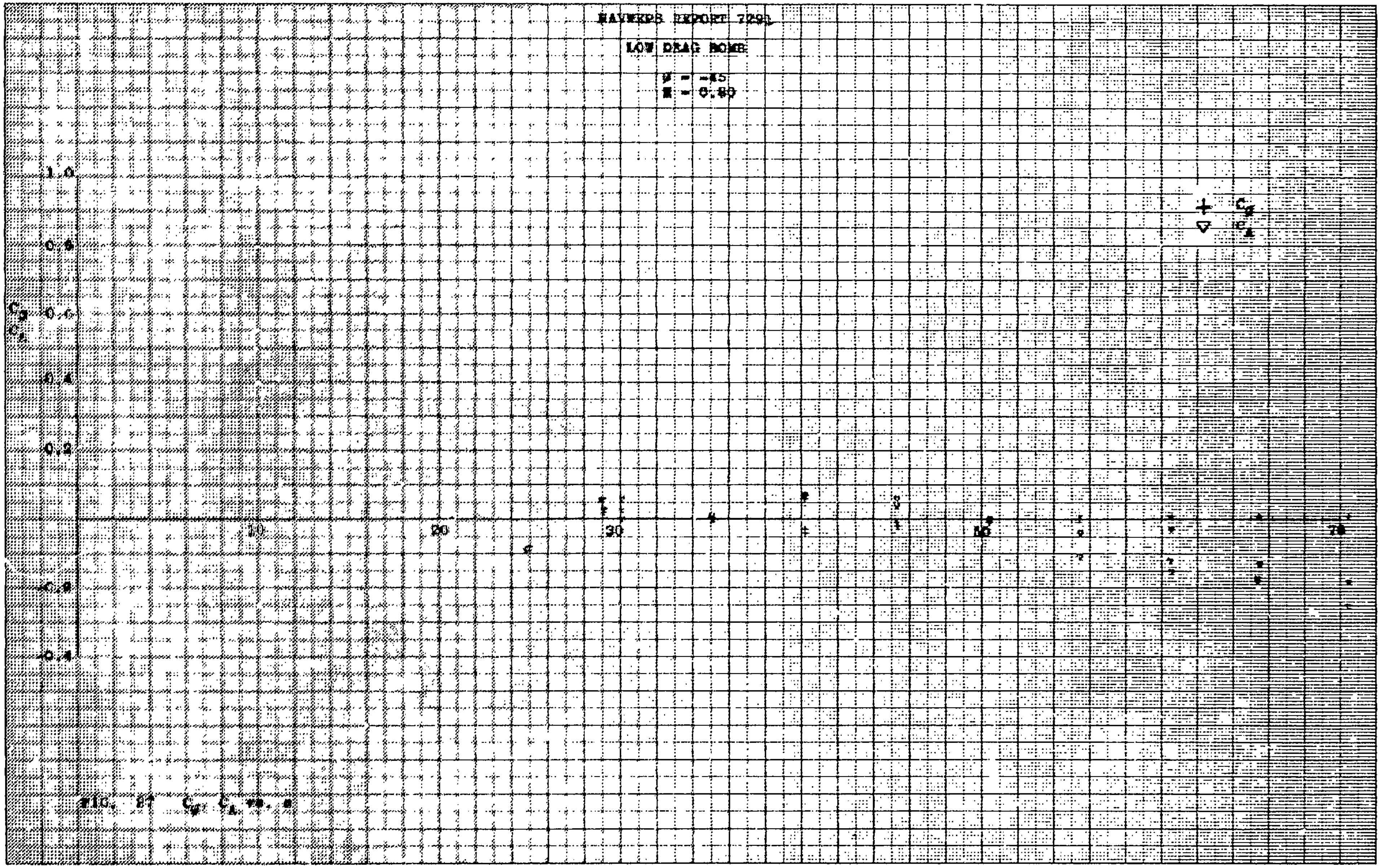


FIG. 27 C_ϕ, C_A vs. α

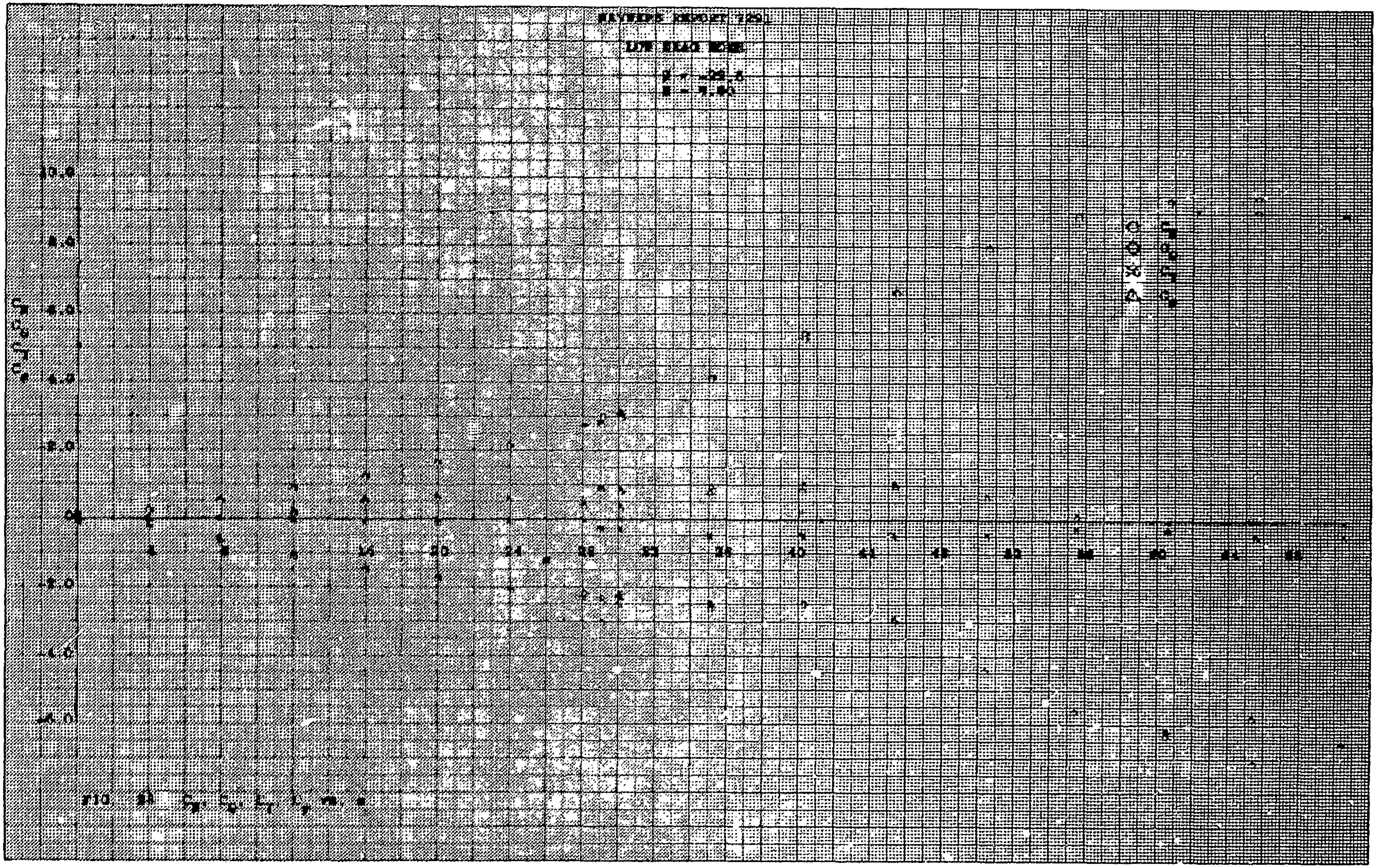


FIG. 23 C_N, C_Y, C_l, C_n vs. α

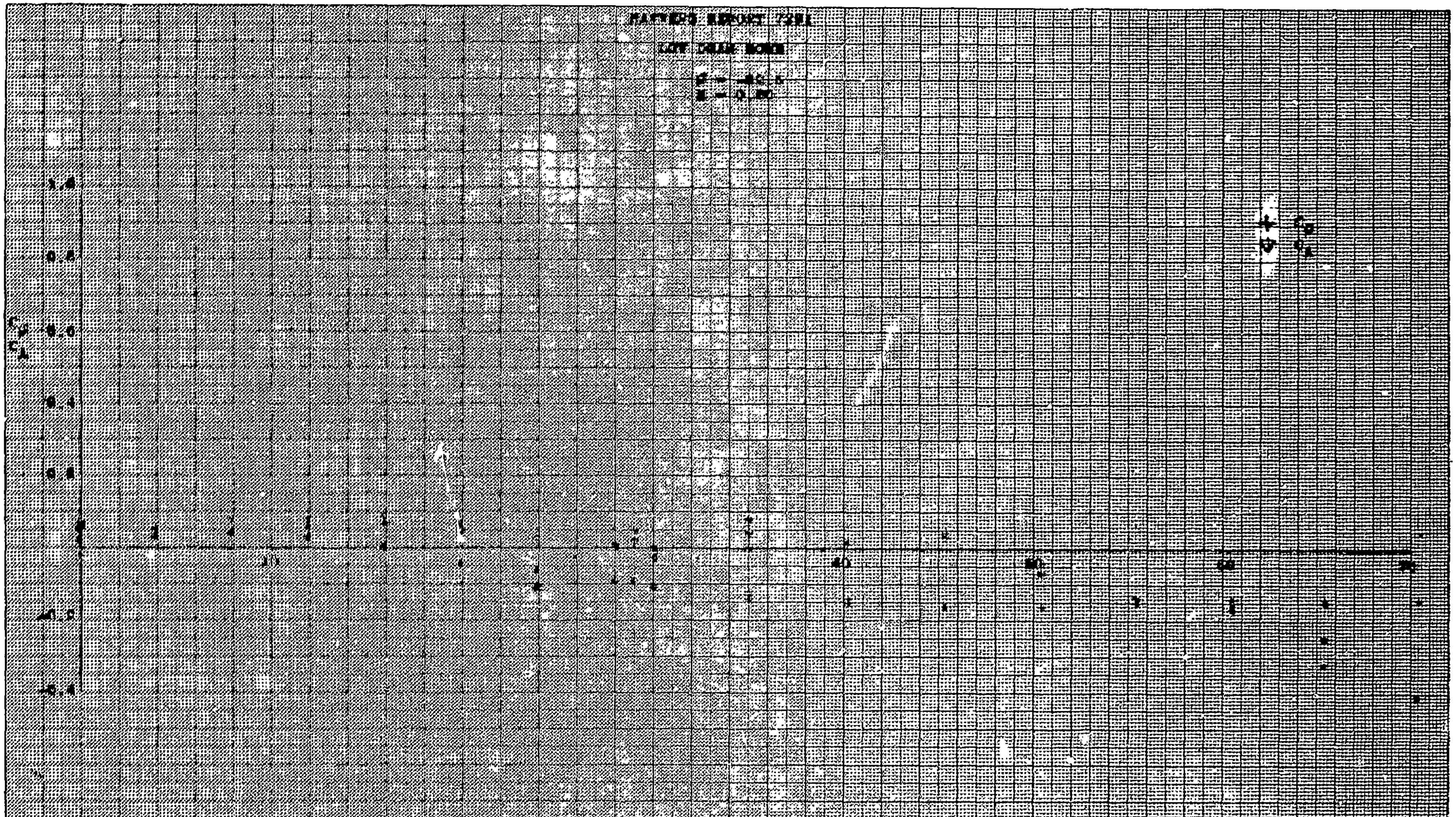
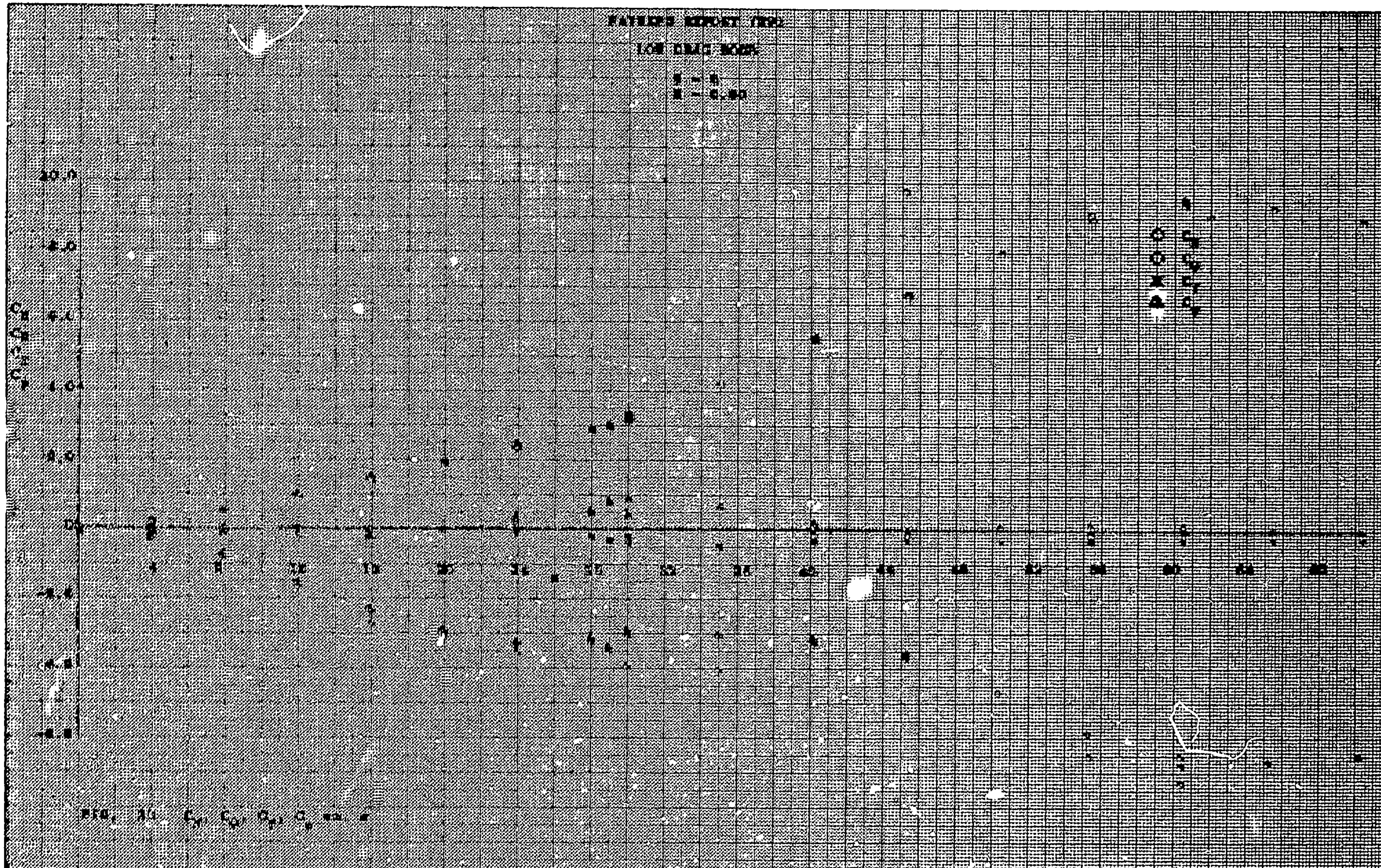


FIG. 28 C_y, C_l vs. α



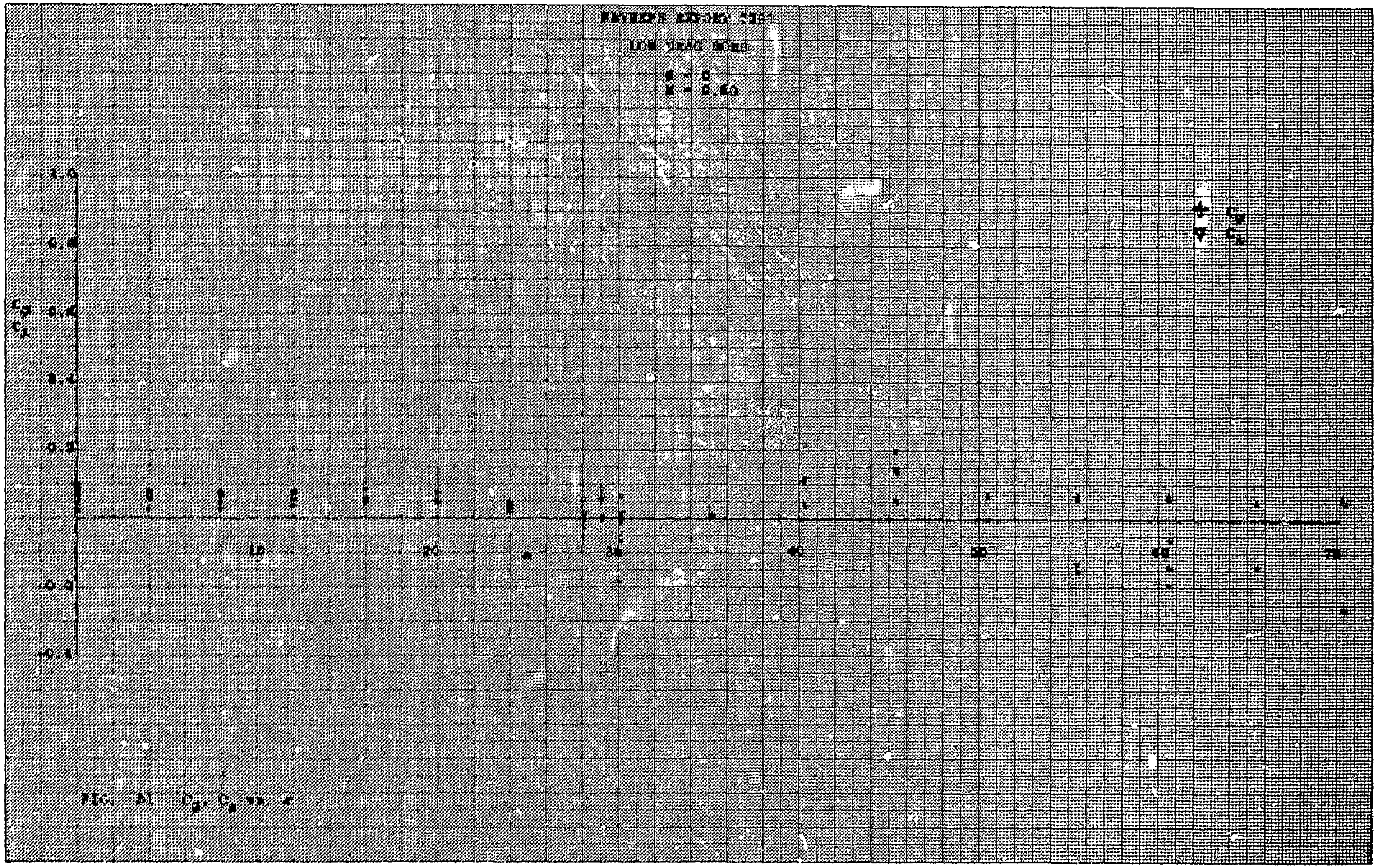


FIG. 31

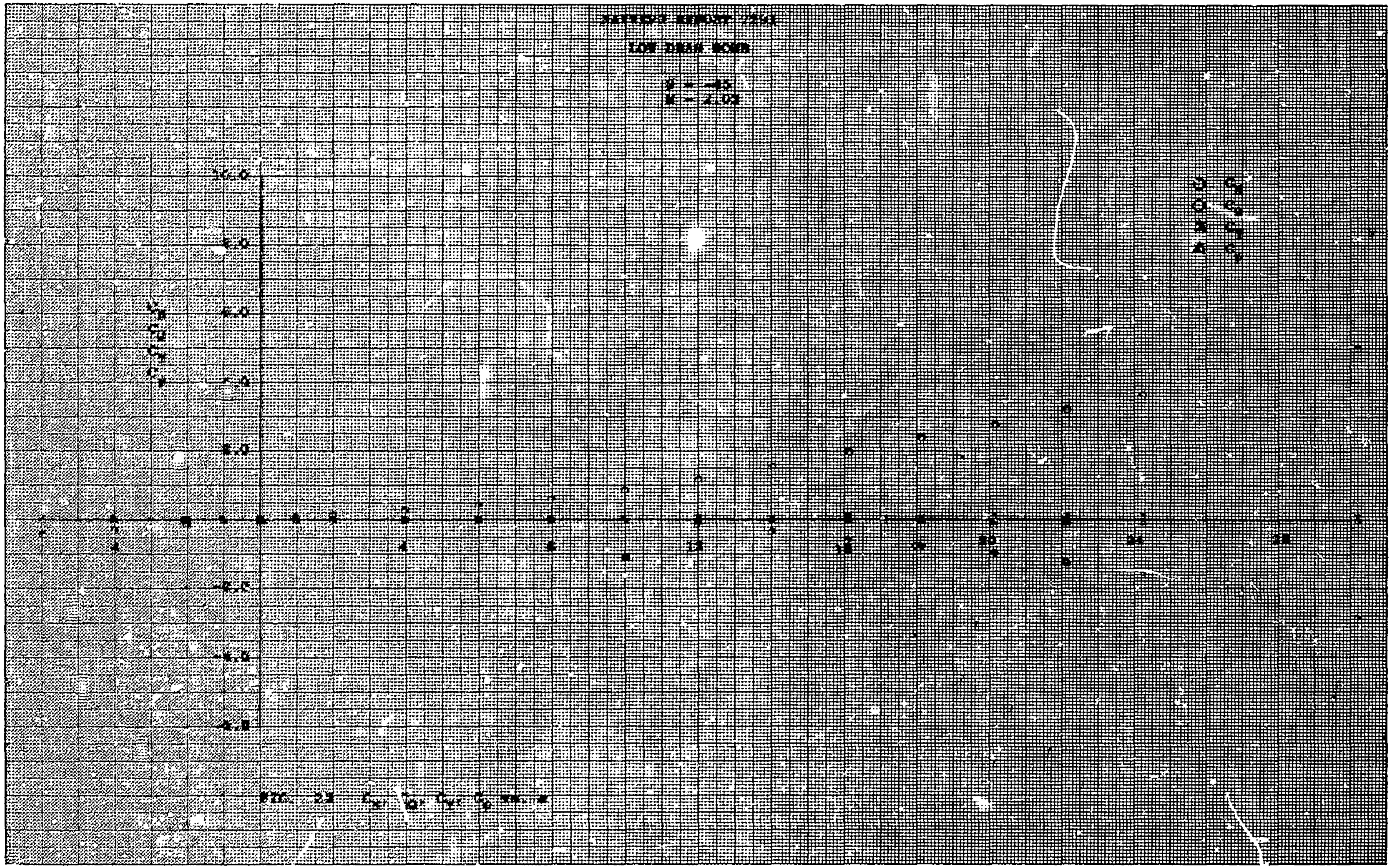


Fig 8

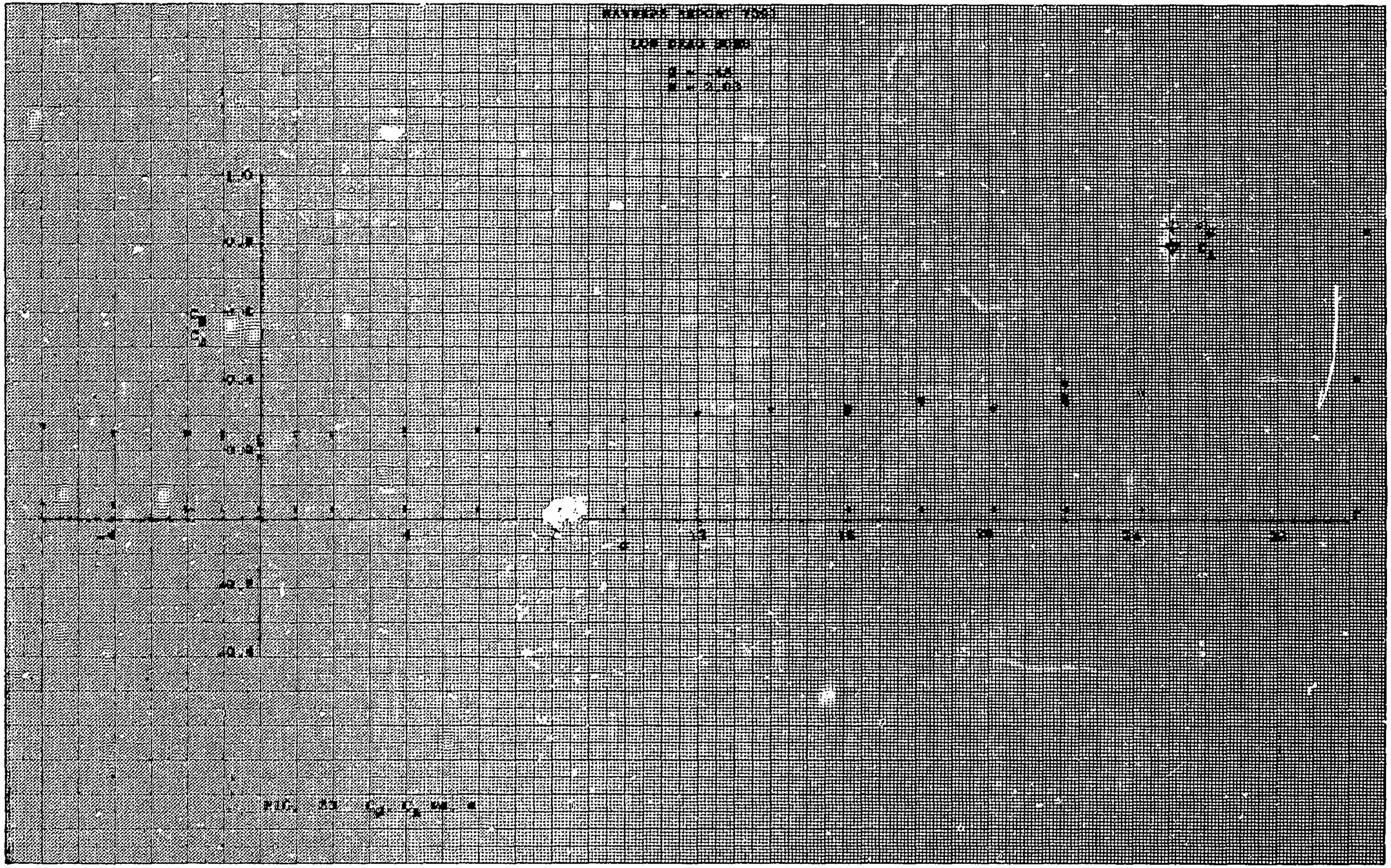


Fig 9

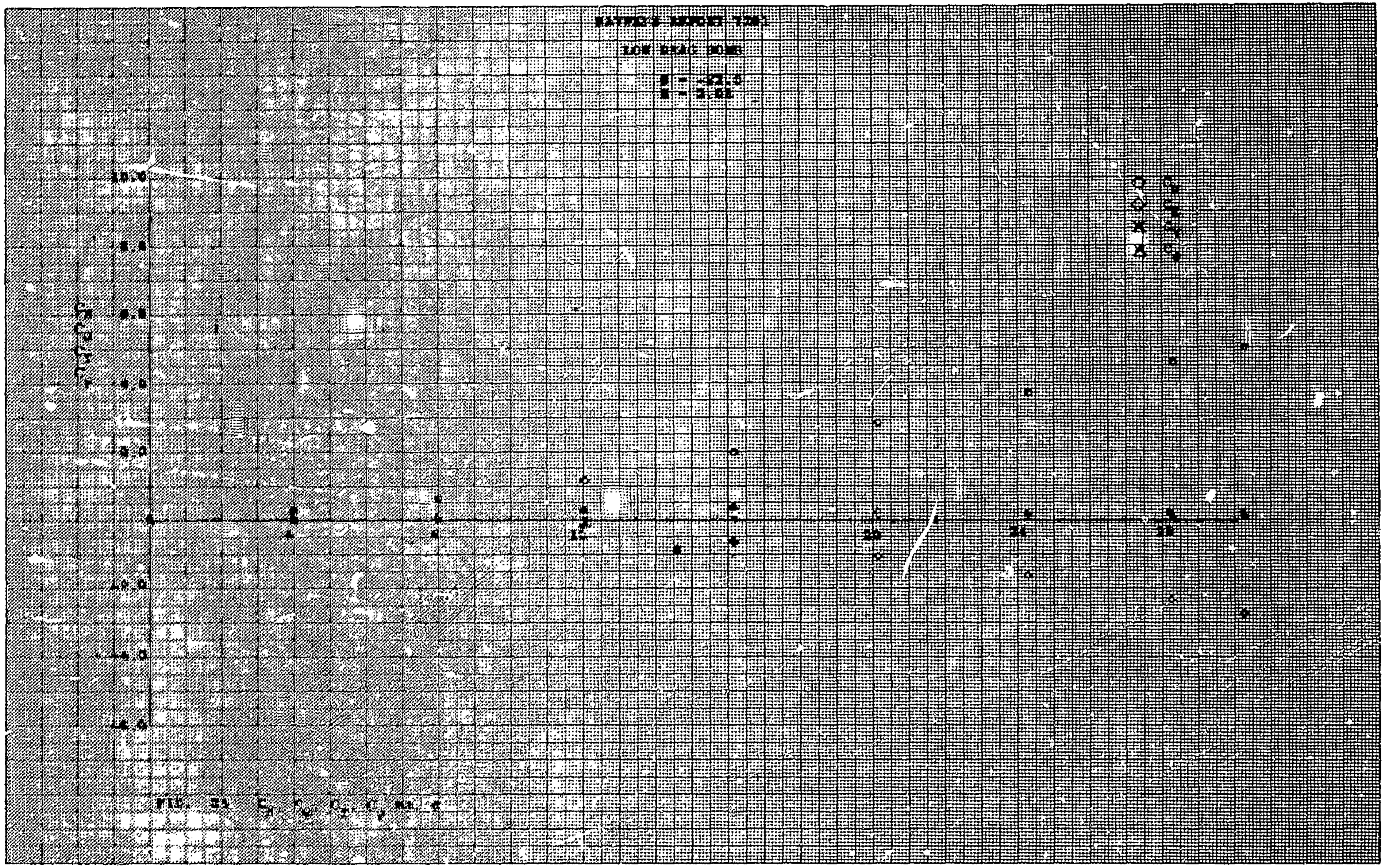


Fig 10

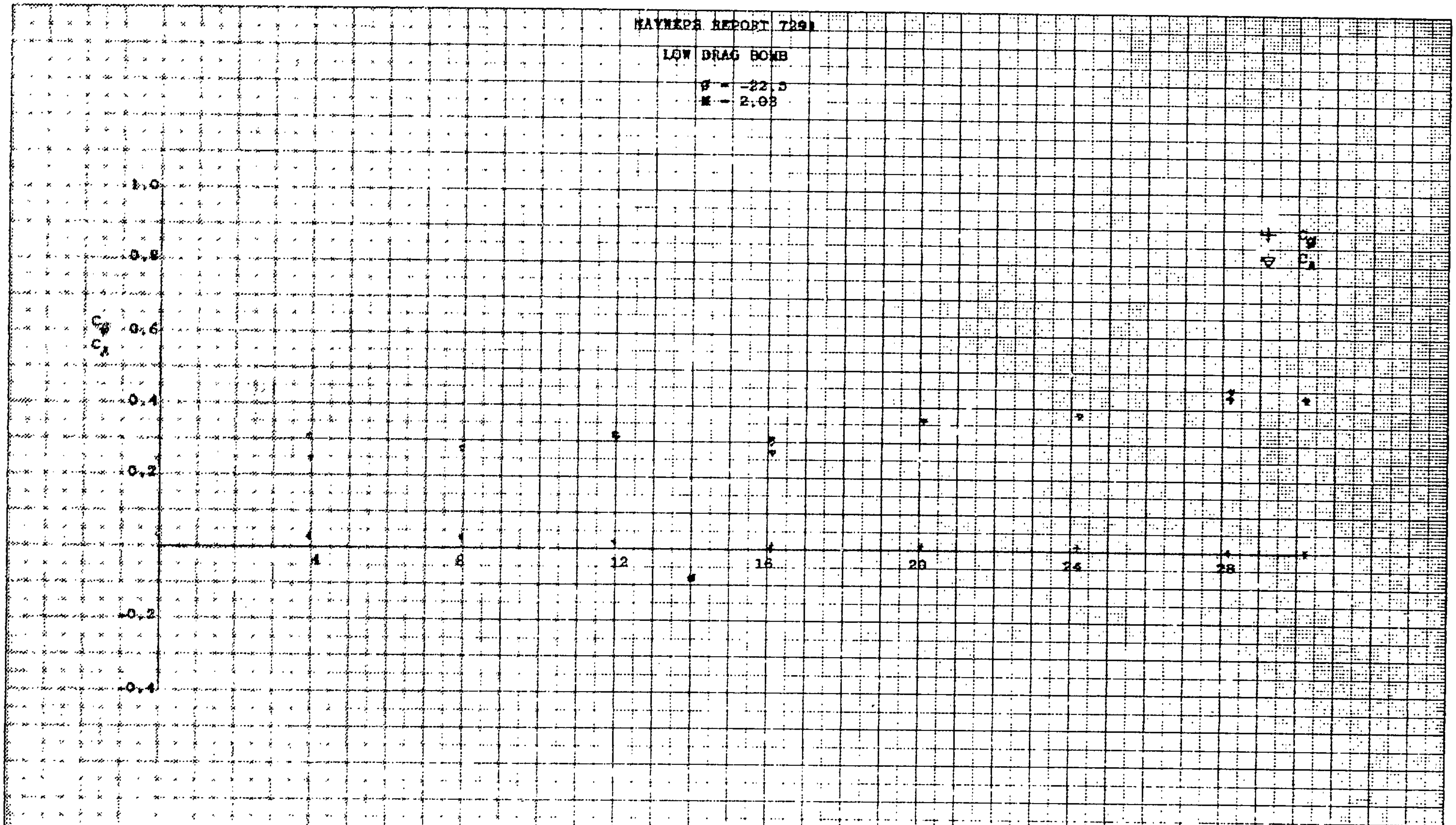


FIG. 35 C_ϕ, C_A vs. α

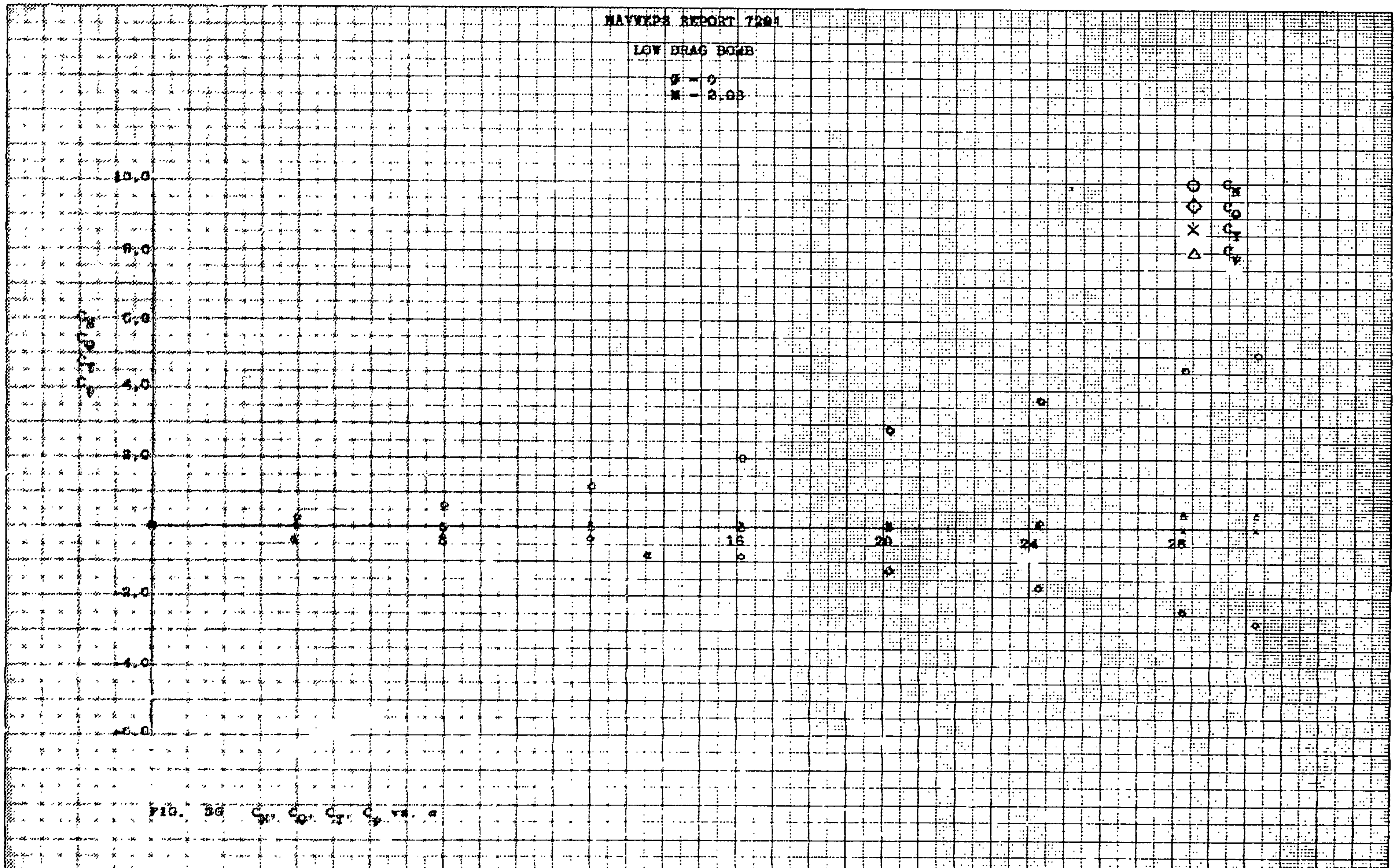


FIG. 3G C_N, C_Q, C_T, C_ψ vs. α

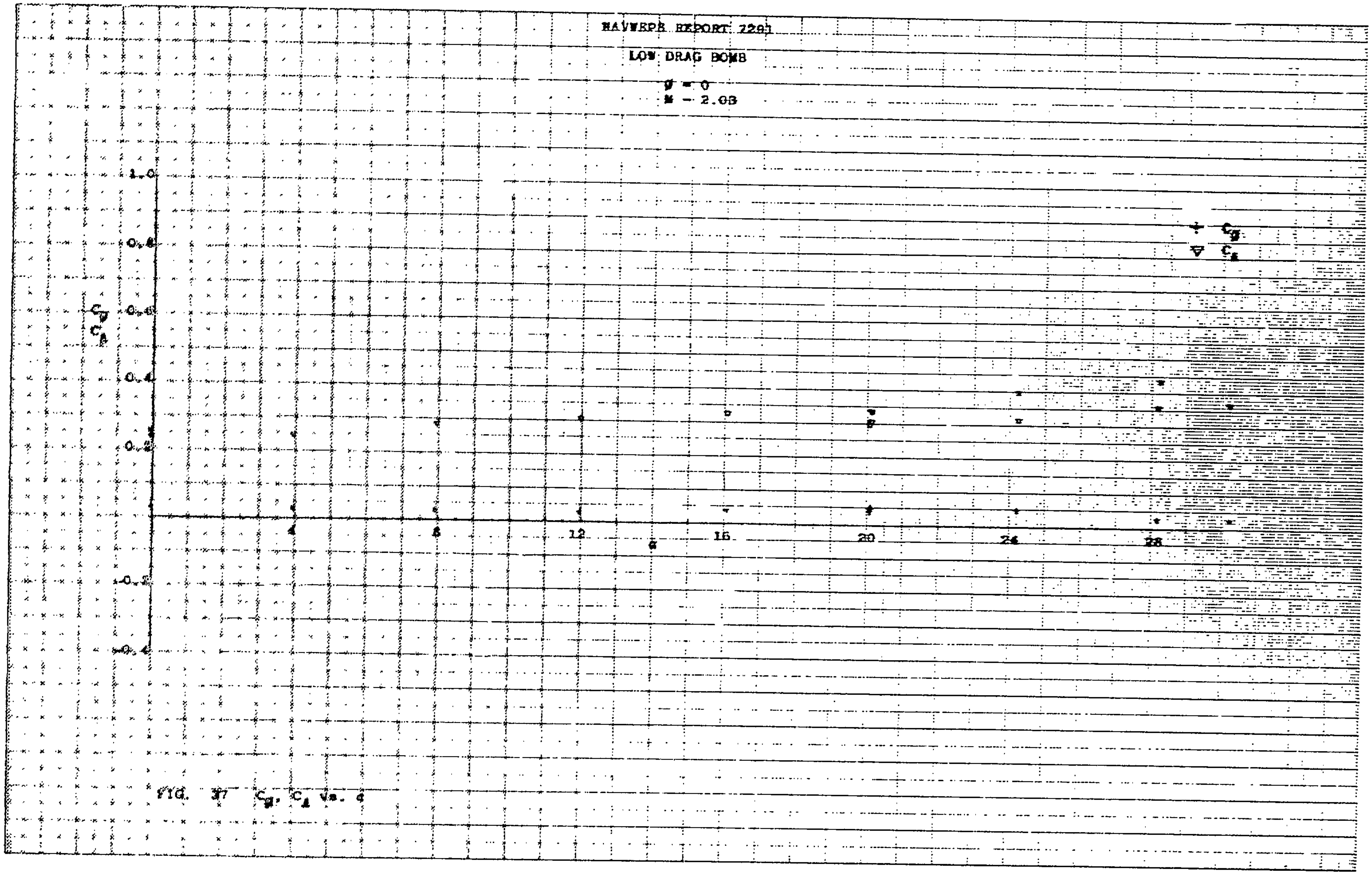


FIG. 37 C_ϕ, C_l vs. α

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This report presents the results of an investigation in the NOL supersonic tunnel no. 1 to measure the static stability and drag of the Navy low-drag bomb at angles of attack up to 70 degrees. These data were obtained at Mach numbers of 0.40, 0.60, 0.80, 1.53, 1.76, and 2.03.

Abstract card is unclassified

1. Bombs, Low drag
2. Bombs - Drag
3. Bombs - Stability
4. Bombs - Wind tunnel tests

I. Title
II. Schermerhorn, Virginia
III. DeMeritte, Fred J., jt. author
IV. Series
V. Project

Naval Ordnance Laboratory, White Oak, Md.
(NAVWEPS report 7291)
WIND-TUNNEL TESTS OF THE NAVY LOW-DRAG BOMB AT ANGLES OF ATTACK UP TO 70 DEGREES, by V.L. Schermerhorn and F.J. DeMeritte. 4 Oct. 1960. 3p. charts, tables, diagrs. (Aerodynamics research report 125). Project 526. UNCLASSIFIED

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IV. Series
V. Project

Naval Ordnance Laboratory, White Oak, Md.
(NAVWEPS report 7291)
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Abstract card is unclassified

1. Bombs, Low drag
2. Bombs - Drag
3. Bombs - Stability
4. Bombs - Wind tunnel tests

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II. Schermerhorn, Virginia
III. DeMeritte, Fred J., jt. author
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